

SWAMP

Sammamish/Washington Analysis and Modeling Program

SMALL STREAMS TOXICITY/PESTICIDE STUDY 2000

November 2002

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Water and Land Resources Division

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Executive Summary

The Small Streams Toxicity/Pesticide Study is intended to assess the potential biological implications associated with the presence of pesticides in selected small streams in King County. Sampling has been conducted since 1999 and will continue through 2003. This report documents methods, results, and conclusions of water quality sampling and testing conducted in 2000. Stormwater and baseflow samples were collected from Lyon Creek, located in the northern Lake Washington drainage basin, and Little Bear and Swamp Creeks, located in the Lake Sammamish drainage basin. In addition, a tributary that drains to the Sammamish River at 124th Street was also evaluated. Finally, Rock Creek, located within a forested part of the City of Seattle watershed, was selected as a reference stream for comparison purposes.

This study was initiated after recent studies detected the presence of pesticides in storm runoff and surface waters in King County and elsewhere (Davis 1993, Davis 1996, Davis 1998, Davis 2000, Voss and Embrey, 2000, Voss et al. 1999). While pesticides have been a concern in the surface waters draining agricultural areas, these studies have shown that small urban and suburban streams can contain a wide variety of pesticides during storm runoff periods. This has led to the hypothesis that chemicals applied to lawns and landscapes are consistently making their way into the aquatic environment through non-point runoff. Water quality standards or guidelines, however, are not available for many of the pesticides present in these streams. While previous studies have characterized the type and concentration of pesticides present in surface water, they were not intended to assess the biological implications of the presence of these compounds in surface waters. As such, the Small Streams Toxicity/Pesticide Study described here was designed to provide a better understanding of the ecological consequences of these pesticides to aquatic life in these study streams through the use of toxicity testing and development of threshold effect concentrations for all compounds detected during this study for which water quality standards are not available.

This study included analysis of: 155 pesticides or transformation products; 18 metals; toxicity using three different test species (*Ceriodaphnia dubia*, *Selenastrum capricornutum*, and *Lemna minor*); total organic carbon and total suspended solids. Samples were collected early and late during one spring storm event, summer baseflow, and a fall storm.

A total of 25 pesticides or pesticide transformation products were detected during the study. The pesticides most frequently detected during storm events included the insecticide diazinon, herbicides 2,4-D, dichlobenil, MCPP, prometon, and trichlopyr, and the insecticide/fungicide pentachlorophenol. These pesticides were either not detected, or detected at lower levels, in the baseflow (June) samples, suggesting storm water runoff is a significant source of pesticides to the suburban streams evaluated.

Toxicity was observed in 19 of 62 toxicity tests conducted using all three test species in all test creeks during the study. Tests conducted on filtered and unfiltered samples indicated that observed toxicity was most often associated with suspended particulates in test samples. The cause of the observed toxicity remains largely uncertain, but does not appear to be caused by the particulates themselves, as total suspended solid concentrations are not near levels shown to adversely affect test species. Also, toxicity was observed most often in samples collected during storm runoff.

Effect threshold concentrations were exceeded twice in the 13 samples analyzed for pesticides. One exceedance was for diazinon in Lyon Creek in the sample collected late in the spring storm event. However, no corresponding toxicity was observed. The other exceedance was also for diazinon in the samples collected from the 124th Street Sammamish River tributary. In this case, toxicity was observed for two of the three test species, which suggests diazinon was the cause. Effects thresholds were not exceeded in the remainder of the samples where toxicity was observed, leaving the cause of observed toxicity uncertain.

Further study will be needed to evaluate whether pesticides are causing adverse effects to aquatic biota during storm events and posing a risk to aquatic communities. In particular future studies should focus on determining causality. In addition to causality, a risk characterization of all likely stressors to a creek community will provide the strongest evidence of whether pesticide runoff associated with storm events are posing an unacceptable risk to suburban creeks.

Information gained from the study will be used by the Sammamish/Washington Analysis and Modeling Program (SWAMP) in the current conditions evaluations in the SWAMP study area. Results of the study may also be incorporated into the Wastewater Treatment Division Habitat Conservation Plan, the environmental impact statement of the Brightwater Treatment Facility Siting project, and an assessment of the potential use of reclaimed water.

ACKNOWLEDGEMENTS

Many individuals at different agencies were part of the Small Stream Toxicity/Pesticide Study. We wish to acknowledge the contributions of the following individuals to the project.

United States Geological Survey:

Jim Ebbert

Sandy Embrey

Lonna Frans

Greg Justin

Alan Haggland

Manchester Environmental Laboratory:

Stuart Magoon

Karin Feddersen

Pam Covey

Bob Carrel

Greg Perez

Jessica Daiker

Kelly Donegan

Charlyn Milne

King County:

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Acronym List

AAM	Algal Assay Medium
AQUIRE	AQ uatic toxicity I nformation RE trieval database
ASTM	American Society for Testing and Materials
BIBI	Benthic Index of Biological Integrity
Ecology	Department of Ecology
HQ	Hazard Quotient
ICP-MS	Inductively-Coupled Plasma Mass Spectrometry
KCEL	King County Environmental Laboratory
NTU	Nephelometric Turbidity Units
NWQL	U.S. Geological Survey National Water Quality Laboratory
SWAMP	Sammamish/Washington Analysis and Modeling Program
TIE	Toxicity Identification Evaluation
TRM	Total Recoverable Metal
TSS	Total Suspended Solids
USEPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey

1. INTRODUCTION

The Small Streams Toxicity/Pesticide Study was initiated in 1999 to assess select small suburban and urban streams in King County for (1) toxicity to aquatic biota; and (2) the presence of chemical contaminants, including pesticides and metals. This report describes the methods and results from Year 2 of this study. The methods and results from Year 1 (1999) can be found on the King County website (<http://dnr.metrokc.gov/wlr/waterres/streams/pestindex.htm>). The following provides background information on this study and summarizes the results of the 1999 study.

1.1. Background

This ongoing study was conducted in cooperation with the United States Geological Survey (USGS), the Department of Ecology (Ecology), and King County. Information obtained from the study will be used by King County's Sammamish/Washington Analysis and Modeling Program (SWAMP) for evaluations of current conditions and water quality in the SWAMP study area. Results of the study may also be incorporated into King County's Wastewater Treatment Division Habitat Conservation Plan, County salmon recovery efforts, and provide environmental information for the Brightwater Wastewater Treatment Facility.

The USGS, Ecology, and others have been studying the distribution of pesticides in the Puget Sound Region for most of the 1990s (Davis 1993, 1996, 1998, 2000; Voss et al. 1999, Voss and Embrey, 2000). Much of this work has involved storm sampling and monitoring current trends in nonpoint pollution. Initial findings focused subsequent evaluations on small suburban and urban streams, where it was observed that the greatest number of pesticides was detected (particularly in watersheds with a high percentage of residential land use). This has led to the hypothesis that chemicals applied to lawns and landscapes are consistently making their way into the aquatic environment through nonpoint source run off. While previous studies have assessed the occurrence and concentrations of pesticides in urban and suburban streams, the Small Streams Toxicity/Pesticide Study is intended to assess the possible biological implications of the presence and concentrations of pesticides in these streams.

1.2. Summary of 1999 Study Results

In 1999, King County collaborated with the USGS and Ecology to collect and analyze samples for pesticides, metals, and toxicity¹ in three small streams: Lyon Creek, Juanita Creek, and Lewis Creek (a fourth creek, Rock Creek, was used as a reference stream). Samples were collected during a spring storm, under summer baseflow conditions, during an early fall storm, and during a late fall storm. The report documenting the 1999 study also included results from a preliminary toxicity assessment of three samples collected in Lyon and Rock Creeks in 1998.

¹ Toxicity was evaluated using the freshwater invertebrate *Ceriodaphnia dubia* (water flea) and the green alga *Selenastrum capricornutum*. Toxicity to *C. dubia* was assessed by evaluating survival and reproductive effects and toxicity to *S. capricornutum* was evaluated based on growth (i.e., cell counts).

The 1999 report concluded, in part, that:

Toxicity to *C. dubia* was observed in Lyon Creek in 1998, but not in 1999.

Toxicity to *S. capricornutum* was observed at least once in samples collected from each of the three streams during 1999.

Toxicity was observed in the streams at different times of the year and under different hydrologic conditions.

Some of the observed toxicity to *S. capricornutum* was likely the result of exposure to a mixture of compounds, including metals and pesticides.

Much of the observed toxicity occurred in the unfiltered² samples, suggesting particulate-bound chemicals may be a possible source of exposure. Identifying the cause of the observed toxicity was determined to require further study.

The 2000 study was designed to further evaluate pesticide concentrations and toxicity in Lyon Creek, as well as two new creeks, Little Bear Creek and Swamp Creek. In addition, samples in 2000 were collected early and late within an individual spring storm, as well as during summer baseflow conditions, and during a fall storm. Finally, pesticide concentrations and toxicity were measured in a small tributary to the Sammamish River just north of Redmond Washington in the Sammamish Valley.

1.3. Report Organization

The remainder of this report is organized as follows:

Section 2 (Methods) – Provides a general description of the study design and study area, as well as the methods for sample collection, analysis of metals and pesticides, and assessing toxicity.

Section 3 (Results) – Summarizes the chemistry and toxicity test results. This section also provides the methods used to develop toxicity thresholds for pesticides and metals detected during this study.

Section 4 (Summary and Conclusions) – Integrates the results of the chemical analyses and toxicity tests to identify whether chemical concentrations in study streams pose a hazard to aquatic biota. Also discussed are seasonal trends, trends within an individual storm event, and important data gaps.

² Toxicity was significantly decreased when samples were filtered prior to testing.

2. METHODS

In general, the 2000 study design was similar to the 1999 study, with the following exceptions:

1. Juanita Creek and Lewis Creek were replaced by Little Bear Creek and Swamp Creek (Lyon Creek was retained). These creeks were included to expand the geographic distribution of small stream toxicity/pesticide data in the SWAMP study area. Furthermore, given their locations in northern King County and southern Snohomish County, they are particularly relevant for providing environmental information for the proposed Brightwater Treatment Facility and its conveyance system.
2. A small irrigation return tributary to the Sammamish River near 124th Street (hereafter referred to the “Sammamish River Irrigation Return”) was sampled and tested for toxicity and chemistry (pesticides, metals) once in early summer. This sample was collected to provide an initial indication of agricultural runoff as a potential source of pesticides and toxicity in the Sammamish River. This initial analysis was intended to determine whether more detailed studies of agricultural runoff are warranted.
3. During the spring sampling event, both early- and late-storm samples were collected in Lyon, Little Bear, and Swamp Creeks. The objective was to determine whether pesticide concentrations changed during the course of an individual storm event. It was hypothesized that pesticide concentrations are greatest early in a storm event due to an initial flushing of land-applied pesticides to creeks. The spring sampling event was selected for this evaluation because it was assumed that pesticide usage is greatest in early spring.

The remainder of this section provides a detailed description of the study creeks, followed by the methods for sample collection, analytical chemistry, and toxicity tests.

2.1. Study Area

As stated above, the sites sampled in the 2000 study were Lyon, Little Bear, and Swamp Creeks, and the Sammamish River Irrigation Return (Figure 2-1). In addition, Rock Creek was used as a reference creek (Figure 2-1). The following summarizes the drainage basis characteristics for each creek.

2.1.1. Lyon Creek

The Lyon Creek drainage basin is approximately 3.7 square miles. Land use is primarily residential (66 percent), with an average residential parcel size of 0.33 acres. A total of 4.7 percent of the land use is commercial and 0.3 percent is industrial. The remaining land use covers 29 percent of the basin. Historically, sockeye and coho salmon and cutthroat and rainbow trout have been observed throughout the creek.

2.1.2. Little Bear Creek

Riparian forested coverage of Little Bear Creek is quite varied, with high coverage (86-100%) in the upper segments and less coverage (0-43 percent) in the middle segments. The percent

riparian forested coverage then increases (88 percent) in the lower reaches of the creek. The total creek subbasin forest coverage is 13.5-16.4 percent (King County 2001a).

During a 2000 habitat survey, juvenile coho salmon (*Oncorhynchus kisutch*) and cutthroat trout (*Oncorhynchus clarki*) were observed throughout Little Bear Creek (King County 2001a). In addition, between September 15 and November 10, 2000 volunteer salmon watchers observed adult coho, sockeye, and kokanee salmon (King County 2001b). An adult Chinook was also found in Little Bear Creek in 1999 (King County 2001a). In addition to salmon, freshwater mussels (Family Unionidae) have been found in Little Bear Creek (King County 2001a).

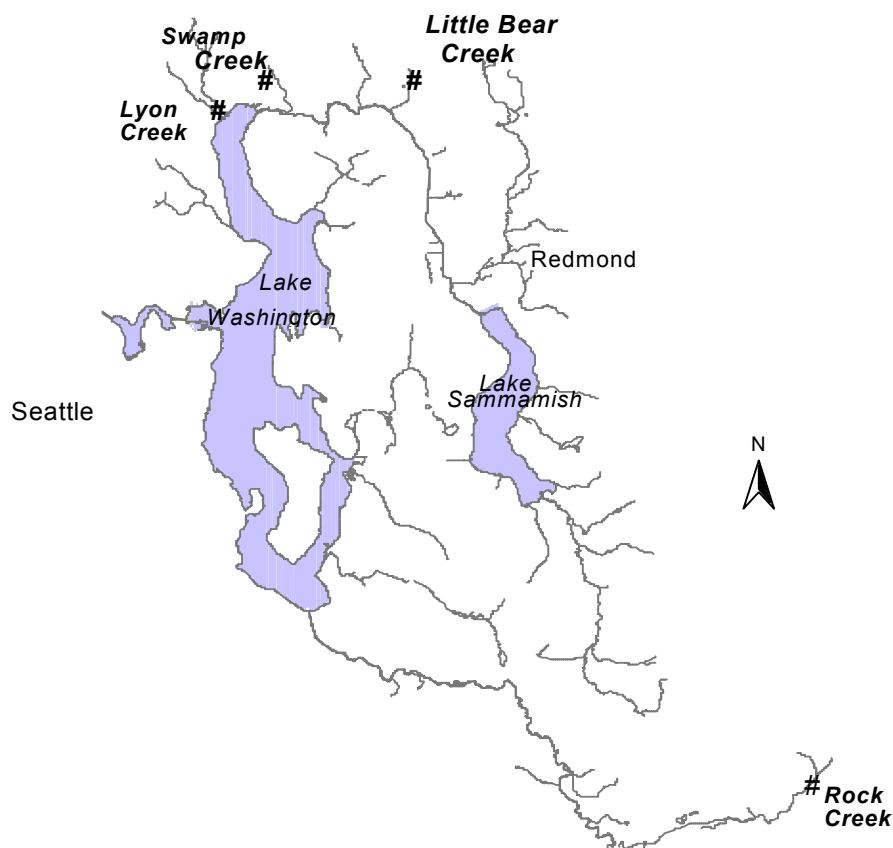


Figure 2-1. Study Area and Stream Locations

2.1.3. Swamp Creek

The Swamp Creek drainage basin is approximately 25 square miles. It is estimated that approximately 52 percent of the Swamp Creek drainage land is impervious (Kerwin 2001). Riparian forested coverage of Swamp is quite varied, with coverage ranging from 0 to 100 percent in the upper segments, 42 to 70 percent in the middle segments, and 17 to 77 percent in the lower segments (King County, 2001a).

Volunteer salmon watchers spotted adult coho, sockeye, and kokanee salmon in Swamp Creek between October 17 and November 16, 2000 (King County 2001b). During a 1999 assessment of Swamp Creek no Chinook salmon were observed, but juvenile coho salmon and cutthroat trout were observed throughout the creek (Mavros et al. 2000). These same species were observed spawning in the upper reaches of Swamp Creek in 1999 by volunteer salmon watchers (Mattila 1999). In addition to salmon, freshwater mussels (Family Unionidae) have also been observed in middle and upper reaches of Swamp Creek (King County 2001a). Mussels are a sensitive indicator of water quality.

2.1.4. Rock Creek

Rock Creek is located in an undeveloped basin within the City of Seattle watershed and was chosen to represent conditions in a relatively pristine forested basin. With the exception of

dicamba in 1999 during the King County Small Streams Toxicity/Pesticide Study, no pesticides were detected in Rock Creek during the 1998 USGS synoptic pesticide study and no other pesticides were detected during this 1999 King County pesticide study.

2.2. Sample Collection

Sample collection methods are detailed in the Small Streams Toxicity Study Sampling and Analysis Plan (SAP) (Appendix A) and summarized below. Samples from Lyon, Little Bear, and Swamp Creeks were collected (1) early and late in a single spring storm event (³); (2) during base flow conditions (June 27); and (3) during a fall storm event (October 9). In addition, the Sammamish River Irrigation Return was sampled once during baseflow conditions in 2000 on September 11. All samples were analyzed for pesticides and metals (Section 2.3) and used in toxicity tests to assess toxicity to aquatic biota (Section 2.4). In addition to pesticides and metals, total hardness, total suspended solids (TSS), total organic carbon (TOC), and dissolved organic carbon (DOC) were analyzed.

Baseflow samples were collected during periods of no rain, while storm sampling was intended to capture contaminant concentrations during the rising stage of the stream during the storm. Studies have shown that some of the highest pesticide concentrations tend to be associated with the “first flush” or the initial wash of stormwater into surface waters (Williams 1998a,b)³. Thus, this study was intended to assess peak inputs of contaminants in an attempt to define the upper limit of toxicity in the stream. Storm sampling was intended to commence when a storm of sufficient magnitude occurred (at least 1/4 to 1/2 inch of rain) and caused visible increased turbidity in the streams.

Dry antecedent conditions were monitored to determine if an upcoming storm would be suitable for evaluation. In the spring, pesticide sales are highest and presumably applications are the greatest (Market Trends Incorporated, 1996). A dry period of a few days to a week would give homeowners and lawn-care professionals a chance to apply pesticides. As such, the “ideal storm” would occur after a weekend of dry weather. Weather predictions and telemetry devices in the Lyon Creek basin that monitored rainfall and stream flow were used to aid the determination of when to mobilize and initiate sampling.

Samples for analysis of toxicity, metals, hardness, TSS, TOC, and DOC were collected as grab samples. Grab samples for low-level metals analysis were collected in general accordance with Method 1669 techniques (USEPA 1996). Field personnel approached the sites from a downstream direction to minimize disturbance, and collected samples while facing upstream in the middle of the creek to minimize the introduction of contamination. Samples for pesticide analyses were collected as discharge-weighted composites (see Appendix B for more detail). Stream hydraulics were monitored by continuously-recording gauges, which have been permanently installed and monitored by King County or the USGS, depending on the stream. The following sections summarize sample collection and handling conditions for each of the sampling events.

³ However, this is more likely to be associated with storms found on the East Coast with long dry periods interrupted by violent 1-2 inch thunderstorms.

2.2.1. Spring Storm

Samples were collected early and late during an individual spring storm. The collection and handling conditions for the early- and late-storm samples are summarized in Table 2-1 and 2-2, respectively. The sampling times and creek flows for Lyon, Little Bear, and Swamp Creeks are shown in Figure 2-2. Hydrographs are not available for Rock Creek.

Table 2-1. Spring 2000 Early Sample Collection, Handling Conditions, and Analyses

Collection Date:	May 3, 2000
Collection Method:	Automatic samplers were set to trigger sample collection when stream stage increased. When the autosampler was triggered, it pumped water from a single point in the stream through a Teflon tube into a glass carboy.
Creeks Sampled / Time / Flow	Lyon Creek / 0930/ 10.93 cubic feet per minute (cfm) Little Bear Creek / 1100/ 27.89 cfm Swamp Creek/ 1200/ 24.37 cfm Rock Creek / Not sampled
Total Rainfall Associated with Storm	0.33 inches
Antecedent Conditions	19 days less than target storm of 0.25 inches
Chemical and Conventional Analyses:	Pesticides, total and dissolved metals, hardness, TSS, TOC, and DOC

Table 2-2. Spring 2000 Late Sample Collection, Handling Conditions, and Analyses

Collection Date:	May 3, 2000
Collection Method:	Flow-weighted composite samples collected for pesticides and total suspended solids. Grab samples collected for toxicity tests and metals.
Creek Sampled / Time / flow	Lyon Creek / 1345/ 8.62 cubic feet per minute (cfm) Little Bear Creek/ 1340/ 24.47 cfm Swamp Creek/ 1500/ 27.96 cfm
Total Rainfall Associated with Storm	0.33 inches
Antecedent Conditions	19 days less than target storm of 0.25 inches
Chemical and Conventional Analyses:	Pesticides, total and dissolved metals, hardness, TSS, TOC, and DOC

2.2.2. Baseflow

Baseflow samples were collected on June 27 in Lyon, Little Bear, and Swamp Creeks, as well as the reference creek, Rock Creek. The collection and handling conditions are summarized in Table 2-3; the sampling time and creek flows are shown in Figure 2-3 for test streams.

The small Irrigation Return tributary to the Sammamish River was sampled during baseflow conditions on September 11 (Table 2-4).

Table 2-3. Baseflow 2000 Sample Collection and Handling Conditions for Lyon, Little Bear, and Swamp Creeks

Collection Date:	June 27, 2000
Collection Method:	Flow-weighted composite samples collected for pesticides and total suspended solids. Grab samples collected for toxicity tests and metals.
Creek Sampled / Time / Flow	Lyon Creek / 1040/ 2.54 cfm Little Bear Creek / 1130/ 11.31 cfm Swamp Creek / 1310/ 4.35 cfm
Total Rainfall Associated with Storm	No Rain
Dry Antecedent Conditions	7 days of no measurable rain
Chemical and Physical Analyses:	Pesticides, total and dissolved metals, hardness, TSS, TOC, and DOC

Table 2-4. Baseflow 2000 Sample Collection, Handling Conditions, and Analyses Conducted for the Sammamish Irrigation Return

Collection Date:	September 11, 2000
Collection Method:	Grab samples collected for toxicity tests, pesticides, metals, and total suspended solids.
Creek Sampled / Time / Flow	124th Street Irrigation Return to the Sammamish River / NA/ NA Rock Creek/ NA/ NA
Total Rainfall of Associated Storm:	No Rain
Dry Antecedent Conditions:	24 hours of no measurable rain
Chemical and Physical Analyses:	Pesticides, total and dissolved metals, hardness, TSS, TOC, and DOC

NA = Not available

Figure 2-2. Spring Storm: Sampling Times and Hydrographs for (a) Lyon Creek, (b) Little Bear Creek, and (c) Swamp Creek.

□ Early storm sample time
△ Late storm sample time

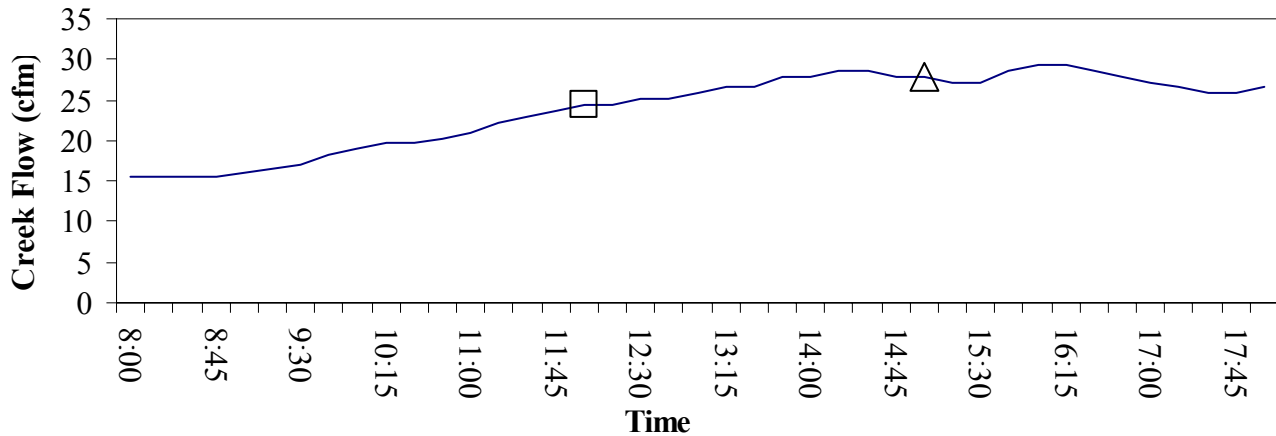
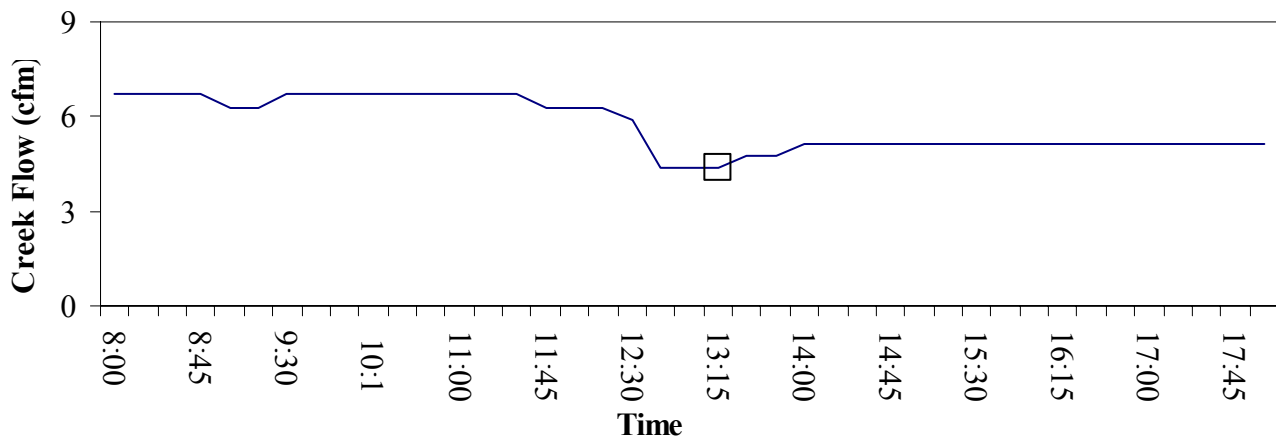


Figure 2-3. Baseflow: Sampling Times and Hydrographs for (a) Lyon Creek, (b) Little Bear Creek, and (c) Swamp Creek. □ Sample time



2.2.3. Fall Storm

Fall storm samples were collected from Lyon, Little Bear, and Swamp Creeks on October 9. The collection and handling conditions are summarized in Table 2-5; sampling times and creek flows are shown in Figure 2-4. The Rock Creek (reference stream) grab sample was collected on October 10, 2000 (hydrographs for Rock Creek are not available).

Table 2-5. Fall 2000 Sample Collection, Handling Conditions, and Analyses Conducted

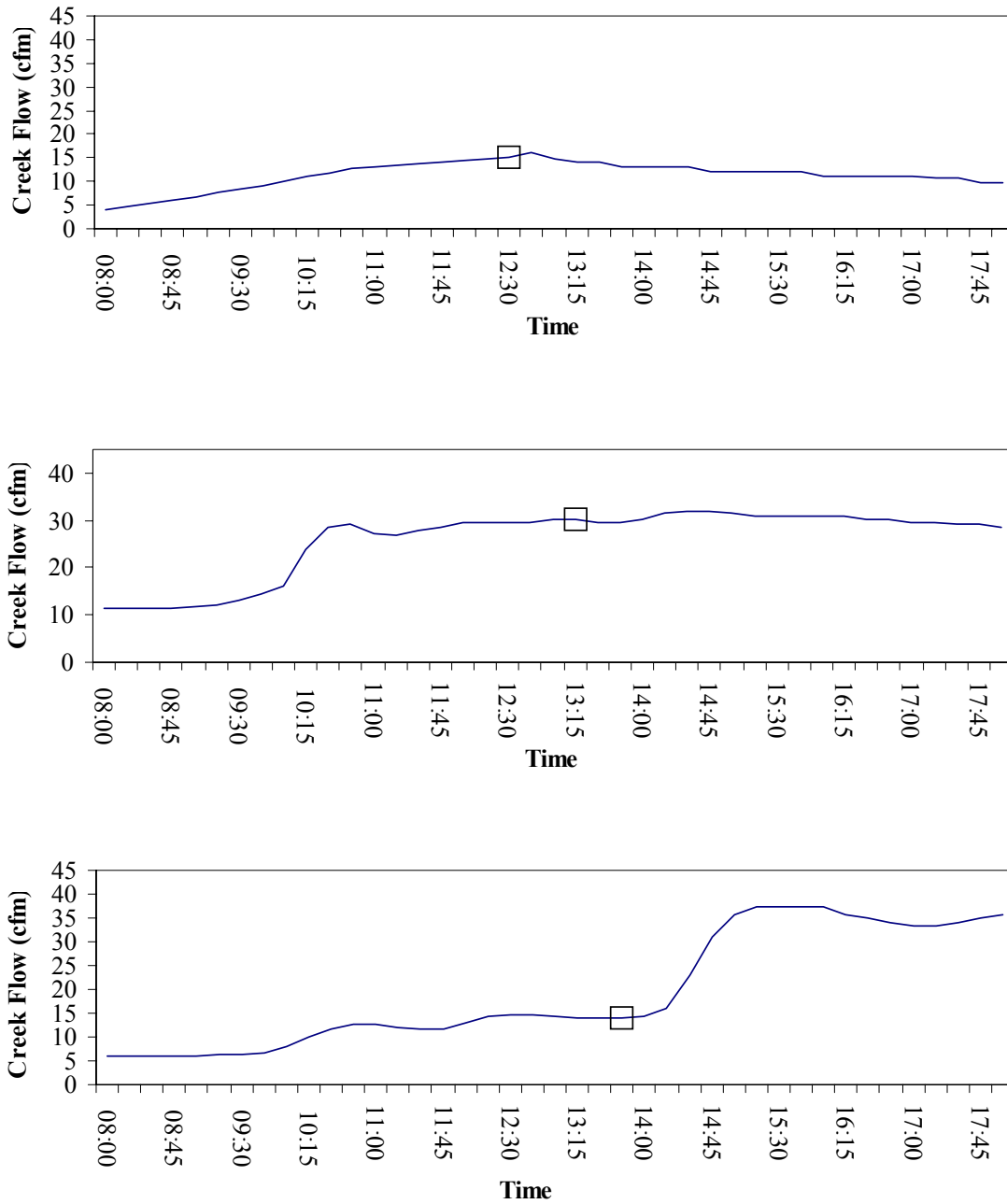
Collection Date:	October 9, 2000
Collection Method:	Automatic samplers were set to trigger sample collection when stream stage increased. When the autosampler was triggered, it pumped water from a single point in the stream through a Teflon tube into a glass carboy.
Creek Sampled / Time / Flow	Lyon Creek / 1230/ 14.29 cfm Little Bear Creek / 1315/ 30.25 cfm Swamp / 1340/ 13.85 cfm
Total Rainfall of Associated Storm:	0.53 inches
Dry Antecedent Conditions	7 days of no measurable rain
Chemical and Physical Analyses:	Pesticides, total and dissolved metals, hardness, TSS, TOC, and DOC

2.3. Analytical Chemistry Methods

As noted earlier, samples were analyzed for pesticides and pesticide transformation products, total and dissolved metals, hardness, TSS, TOC, and DOC. These samples were collected concurrently with the toxicity test samples. Non-pesticide organic chemicals were not analyzed in this study.

Pesticide analyses were conducted at the U.S. Geological Survey National Water Quality Laboratory (NWQL) in Denver, Colorado, and the Washington State Department of Ecology Manchester Environmental Laboratory, in Manchester, Washington. Pesticides analyzed by the USGS laboratory included 26 herbicides, 18 insecticides, and 3 transformation products, for a total of 47 analytes. Pesticides analyzed by the Ecology Manchester Laboratory included 12 fungicides, 61 herbicides, 59 insecticides, and 12 transformation products, for a total of 144 analytes. Thirty-six of the analytes measured by USGS were also measured by Ecology; therefore, a total of 155 analytes were analyzed by the two laboratories. Detailed methods for pesticides analyses are described in Appendix B.

Figure 2-4. Fall Storm: Sampling Times and Hydrographs for (a) Lyon Creek, (b) Little Bear Creek, and (c) Swamp Creek.
 Sample time



Total and dissolved metals, hardness, TSS, TOC, and DOC were analyzed at the King County Environmental Laboratory (KCEL) in Seattle, Washington. The samples were analyzed by inductively coupled plasma mass spectrometry (ICP-MS) for aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc. Mercury was determined by cold-vapor atomic absorbance. Hardness was calculated from calcium and magnesium concentrations as determined by ICP and TSS was determined by EPA Method CV SM2540-D.

2.4. Toxicity Test Methods

Toxicity tests were conducted using an invertebrate (*Ceriodaphnia dubia*) and a unicellular green alga (*Selenastrum capricornutum*), both of which were tested in the 1999 study. For the 2000 study, a vascular aquatic plant (*Lemna minor*) was also tested in toxicity tests as a means to evaluate herbicides not toxic to algae. These organisms were selected because they are common test organisms, standard toxicity test methods are available for each, and chronic (long-term) toxicity tests can be conducted in ≤ 7 days. Furthermore, these three test organisms were selected because they have unique physiologies and react differently to chemical exposures depending on the chemical's mode of toxic action. All toxicity tests were conducted at the KCEL. The following sections summarize the toxicity test methods for each test organism.

2.4.1. *Ceriodaphnia dubia*

Chronic *C. dubia* toxicity tests were conducted according to USEPA guidelines. The exposure duration of the chronic toxicity tests was seven days and the endpoints evaluated were reproduction and survival. Toxicity tests were conducted on both filtered and unfiltered creek samples to assess (1) whether observed toxicity (if any) is a function of dissolved or particulate-bound chemical; or (2) a function of TSS directly. Samples were filtered using a 0.45 μm acrylic copolymer capsule filters. Toxicity test methods for *C. dubia* are summarized in Table 2-6.

2.4.2. *Selenastrum capricornutum*

Chronic *S. capricornutum* toxicity tests were conducted according to USEPA guidelines. The exposure duration of the toxicity tests was 96 hours and the endpoint evaluated was growth (measured using cell counts). Like the *C. dubia* toxicity tests, the toxicity tests were conducted using both filtered and unfiltered creek water. Toxicity tests methods for *S. capricornutum* are summarized in Table 2-7.

2.4.3. *Lemna minor*

Chronic *L. minor* toxicity tests were conducted according to ASTM (1988), which was modified by using (1) static-renewal of creek water during the exposure; and (2) Hoagland's medium at 10 percent of full strength. This latter modification to the ASTM (1988) toxicity test method was necessary to allow the sample to be adjusted to $\text{pH} \geq 7.0$ without precipitation of medium components. Furthermore, this modification reduced the possibility of masking the chemical nature of the sample with constituents of the Hoagland's medium. Because the medium was diluted, static-renewal of the creek water was necessary to ensure an adequate level of nutrients for plant growth. Test conditions for this test are provided in Table 2-8.

Table 2-6. Summary of Test Conditions for the Chronic *Ceriodaphnia dubia* Toxicity tests

Test Protocol	<i>Methods for Measuring the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms EPA/600/4-91/002, August 1994 [see USEPA, 1999. Errata for the Effluent and Receiving Water Toxicity Testing Manuals. EPA-600/R-98/182].</i>
Test Material	Stream sample
Test Organisms/age	<i>Ceriodaphnia dubia</i> ; 24 hrs old
Source of Organisms	In-house culture
Number/Test Chamber	1
Volume/Test Chamber	15 mL
Test Concentrations	100% stream sample and control
Replicates	Ten
Reference Toxicant	Cadmium (as cadmium nitrate)
Test Duration	7 days
Control/Dilution Media	Lake Washington water
Test Chambers	30 mL plastic cups
Lighting	Fluorescent bulbs (50-100 foot candles)
Photoperiod	16 hours light; 8 hours dark
Aeration	None
Feeding	Daily (0.1 mL YCT and 0.05 mL algal suspension at 3.6×10^6 cells/mL)
Renewal	Daily (100%)
Temperature	$25 \pm 1^\circ\text{C}$
Monitoring Data	Dissolved oxygen, temperature, and pH at test initiation and every 24 hours; specific conductivity, hardness, and alkalinity
Effect Measured	Mortality and reproduction
Test Acceptability	Control mortality $\leq 20\%$ and 60% of surviving adults in the controls must have at least 3 broods, with an average total number of 15 or more neonates per surviving adult.

Table 2-7. Summary of Test Conditions for the Chronic *Selenastrum capricornutum* Toxicity Tests

Test Protocol	<i>Methods for Measuring the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms</i> EPA/600/4-91/002, August 1994 [see USEPA, 1999. Errata for the Effluent and Receiving Water Toxicity Testing Manuals. EPA-600/R-98/182].
Test Material	Stream sample
Test Organisms/Age	<i>Selenastrum capricornutum</i> ; 4-7 days from culture renewal
Source	In-house culture, originally obtained from the American Type Culture Collection (12301 Park Lawn Dr., Rockville, Maryland 20852)
Number/Container	10,000 cells/mL at test initiation
Volume/Container	50 mL
Test Concentrations	100% stream sample and control
Replicates	Four
Reference Toxicant	Sodium chloride
Test Duration	96 hours
Control/Dilution Media	Algal assay medium
Test Chambers	125 mL glass Erlenmeyer flasks
Lighting	$86 \pm 8.6 \mu\text{E}/\text{m}^2/\text{s}$ (400 ± 40 ft-c or 4300 ± 430 lux)
Photoperiod	Continuous illumination
Shaking Rate	Twice daily, by hand
Temperature	$25 \pm 1^\circ \text{C}$
Monitoring Data	Temperature at initiation and every 24 hours; pH at initiation and termination of test
Effect Measured	Cell growth
Test Acceptability	Control $\geq 1.0 \times 10^6$ cells/mL

Table 2-8. Summary of Test Conditions for the Chronic *Lemna minor* Toxicity Tests

Test Protocol	Proposed new standard guide for conducting static and acute toxicity tests with duckweed. Draft #7. ASTM 1988.
Test Material	Stream sample
Test Organisms/Age	<i>Lemna minor</i> ; 3-frond
Source	Illinois State Water Survey, November 11, 1988
Number/Container	3, 3-frond plants
Volume/Container	50 mL
Test Concentrations	100% stream sample and control
Replicates	Four
Reference Toxicant	Sodium chloride
Test Duration	7 days
Control/Dilution Media	Hoagland's medium at 10% full strength
Test Chambers	100 mL glass beakers
Lighting	$86 \pm 8.6 \mu\text{E}/\text{m}^2/\text{s}$ (400 ± 40 ft-c or 4300 ± 430 lux)
Photoperiod	Continuous illumination
Renewal	Daily (100%)
Temperature	$25 \pm 1^\circ \text{C}$
Chemical Data	Temperature and pH at initiation and every 24 hours
Effect Measured	Growth
Test Acceptability	Growth (dry weight) of control > 3 times the dry weight of the inoculum

3. RESULTS

This section presents the analytical chemistry and toxicity test results. The summary of analytical chemistry results includes a comparison of detected concentrations to effects thresholds for aquatic life.

3.1. Analytical Chemistry

Of the 155 pesticides and 18 metals for which samples were analyzed, a total of 25 pesticides and 12 metals were detected in at least one sample from Lyon, Little Bear, or Swamp Creeks, or the Sammamish River Irrigation Return (Table 3-1). The pesticides and metals not detected in any sample are provided in Table 3-2. Detailed analytical results are provided in Appendix B and C for pesticides and metals, respectively. The pesticide and metals results are discussed separately in the following sections.

Table 3-1. Parameters Detected in Test Creeks in 2000

Analyte	Streams												Irrigation Return
	Lyon				Swamp				Little Bear				
	May-Early	May-Late	June	October	May-Early	May-Late	June	October	May-Early	May-Late	June	October	
													September
Pesticides													
2,4-D	X	X		X	X	X		X	X	X		X	X
2,6-Dichlorobenzamide	-	-	-	-	-	-	-	-	-	-	-	-	X
4-Nitrophenol				X				X				X	
Atrazine	X	X	X				X		X				
Bromacil		X									X		
Carbaryl	X	X							X				
Carbofuran													X
Chlorpyrifos	X	X											X
Desethylatrazine			X								X		
Diazinon	X	X	X	X	X	X	X	X	X	X	X	X	X
Dicamba				X								X	X
Dichlobenil	X	X	X	X	X	X	X	X	X	X	X	X	X
Diuron													X
Ethofumesate	-	-	-	-	-	-	-	-	-	-	-	-	X
Malathion					X	X							

Analyte	Streams												Irrigation Return
	Lyon				Swamp				Little Bear				
	May-Early	May-Late	June	October	May-Early	May-Late	June	October	May-Early	May-Late	June	October	September
MCPA	X	X			X	X			X				
MCPP	X	X		X	X	X		X	X	X		X	
Metalaxyl													X
Metolachlor													X
Pentachlorophenol	X	X		X	X	X		X	X	X		X	X
Prometon	X	X	X	X	X	X	X	X	X	X	X	X	X
Simazine	X	X	X	X			X				X		
Tebuthiuron			X						X	X	X		X
Trichlorpyr	X	X		X	X	X		X	X	X		X	X
Trifluralin			X										X
Metals													
Aluminum	-	-	-	-	-	-	-	-	-	-	X	-	X
Arsenic	X			X								X	X
Barium	X	X	X	X	X	X	X	X	X	X	X	X	X
Chromium	X	X	X	X					X	X		X	X
Cobalt				X									X
Copper	X	X	X	X		X		X	X	X		X	X
Lead	X	X	X	X		X		X	X	X		X	
Nickel	X	X	X	X	X	X		X	X	X		X	X
Vanadium	X	X	X	X	X	X	X	X	X	X	X	X	X
Zinc	X	X	X	X	X	X		X	X	X	X	X	X

- indicates analyte not measured.

Table 3-2. Parameters Measured But Never Detected in any of the Study Creeks

Pesticides		
2,3,4,5-Tetrachlorophenol	2,4,5-Trichlorophenol	Acetochlor
2,3,4,6-Tetrachlorophenol	2,4,6-Trichlorophenol	Acifluorfen
2,4'-DDD	2,4-DB	Alachlor
2,4'-DDE	2,6-Diethylaniline	Aldrin
2,4'-DDT	3,5-Dichlorobenzoic Acid	alpha-Chlordene
2,4,5-T	4,4'-DDD	alpha-HCH
2,4,5-TB	4,4'-DDE	Ametryn
2,4,5-TP	4,4'-DDT	Atraton
Azinphos ethyl	Endrin	Parathion
Azinphos-methyl	Endrin Aldehyde	Pebulate
Benfluralin (Benefin)	Endrin Ketone	Pendimethalin
Bentazon	EPN	Phorate
beta-HCH	EPTC (Eptam)	Phosphamidan
Bromoxynil	Ethalfuralin	Picloram
Butachlor	Ethion	Profluralin
Butylate	Ethoprop	Prometryn
Captafol	Fenamiphos	Pronamide
Captan	Fenarimol	Propachlor
Carbofuran	Fenitrothion	Propanil
Carbophenothion	Fensulfothion	Propargite
Carboxin	Fenthion	Propazine
Chlorothalonil	Fluridone	Propetamphos
Chlorpropham	Fonofos	Ronnel
Cis-Chlordane	gamma-Chlordene	Sulfotep
cis-Nonachlor	gamma-HCH	Sulprofos
cis-Permethrin	Heptachlor	Temephos
Coumaphos	Heptachlor Epoxide	Terbacil
Cyanazine	Hexazinone	Terbufos
Cycloate	Imidan	Terbutryn
DCPA	Ioxynil	Tetrachlorvinphos
DDMU	Kelthane	Thiobencarb
delta-HCH	Linuron	Toxaphene
Demeton-O	Merphos (1 & 2)	trans-Chlordane
Demeton-S	Methoxychlor	trans-Nonachlor

Pesticides		
Di-allate	Methyl Chlorpyrifos	Triadimefon
Dichlorprop	Methyl Paraoxon	Triallate
Dichlorvos	Methyl Parathion	Tribufos
Diclofop-Methyl	Metribuzin	Vernolate
Dieldrin	Mevinphos	
Dimethoate	MGK264	Metals
Dinoseb	Mirex	Antimony Beryllium
Dioxathion	Molinate	Cadmium Mercury
Diphenamid	Napropamide	Molybdenum Selenium
Disulfoton	Norflurazon	Silver Thallium
Endosulfan I	Oxychlorthane	
Endosulfan II	Oxyfluorfen	
Endosulfan Sulfate		

3.1.1. Pesticides

As shown in Table 3-1, 19 of the 25 pesticides detected in the 2000 study were measured in samples from Lyon, Little Bear, and/or Swamp Creek (the remaining six pesticides were only analyzed or detected in the Sammamish River Irrigation Return). For each of the 19 pesticides detected in study creeks, Figures 3-1 to 3-19 show the measured concentrations by stream and sampling time. The figures also show the pesticide effects threshold, as described and presented in King County (2002). If a pesticide was not detected in a sample, it is plotted as a “less than” value equivalent to the detection limit. Finally, for those pesticides analyzed by both the USGS and Ecology Manchester laboratories (Section 2.3), the following rules were used: (1) if the pesticide was detected by both laboratories, the mean concentration is shown; (2) if the pesticide was detected by only one laboratory, the mean of the detected concentration and the detection limit in the undetected sample is shown; and (3) if the pesticide was not detected by either laboratory, the lowest detection limit is shown.

With the exception of diazinon in the Lyon Creek sample collected late in the May storm (Figure 3-8), no additional pesticides in Lyon, Little Bear, or Swamp Creeks were detected at concentrations above their effects thresholds in any sample. The one effects threshold exceedance by diazinon in the Lyon Creek sample was based on a detected concentration of 0.11 µg/L (compared to an effects threshold of 0.09 µg/L). In general, the remaining detected pesticide concentrations were often one or more orders of magnitude below their respective effects thresholds. Ratios of pesticide concentrations to their respective effects thresholds are provided in Appendix E.

As discussed previously, stream samples were collected early and late within a single May storm. The objective was to determine whether pesticide concentrations are highest early in the storm following the initial runoff of storm water into the streams. Overall, a consistent pattern in the relative pesticide concentrations early and late in a storm was not observed. Of 57 possible comparisons (3 streams x 19 pesticides), the early storm pesticide concentration was greater than the late storm concentration in 17 samples (30 percent). In 12 samples (21 percent), the late

storm pesticide concentration was greater than the early storm concentration. Pesticides in the remaining samples were either not detected or, in one sample, the early and late storm concentration was the same.

Stream samples were collected during storms in May and October to assess the potential influence of different use scenarios and antecedent conditions in the study area. For example, application rates of many pesticides are likely to be different in the spring compared to early fall. In addition, the duration of dry antecedent conditions prior to the storm is likely to be greater in the fall than in spring. Seasonal differences in pesticide concentrations can be seen in Figures 3-1 to 3-19. In general, pesticide concentrations during the May and October storm events are greater than under baseflow conditions in early summer. Furthermore, more pesticides were detected during the May storm event than the October storm. The number of detected pesticides from May (early in storm) vs. October were 11 vs. 9 in Little Bear Creek, 12 vs. 9 in Lyon Creek, and 9 vs. 8 in Swamp Creek. However, this comparison is only a rough approximation because detection limits often differed in the spring and fall samples.

As shown in Table 3-1, 16 pesticides were also detected in the water sample collected from the Sammamish River Irrigation Return on September 11, 2000. Concentrations of detected pesticides in the Irrigation Return and their associated effects thresholds are provided in Table 3-3. As for the study creeks discussed above, diazinon was the only pesticide detected at a concentration greater than its effects threshold.

Table 3-3. Pesticide Concentrations Detected in the Sammamish River Irrigation Return in September, 2000

Pesticide	Concentration (µg/L)	Effects Threshold (µg/L)
2,4-D	0.28	30
2,6-Dichlorobenzamide	0.21	13,416
Carbofuran	0.229	0.8
Chlorpyrifos	0.005	0.041
Diazinon	0.586	0.09
Dicamba	0.38	30.5
Dichlobenil	0.041	3,100
Diuron	0.052	4
Ethofumesate	2.4	9.1
Metalaxyl	0.15	6,250
Metolachlor	0.007	5
Pentachlorophenol	0.029	9.5 ^a
Prometon	0.007	49
Tebuthiuron	0.076	25
Trichlorpyr	0.28	150
Trifluralin	0.003	3.2

Bold and underlined pesticide concentrations exceed the effects threshold.

^aAssuming a pH of 7.5, the mean pH of the toxicity test samples.

Figure 3-1. Concentrations of 2,4-D in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

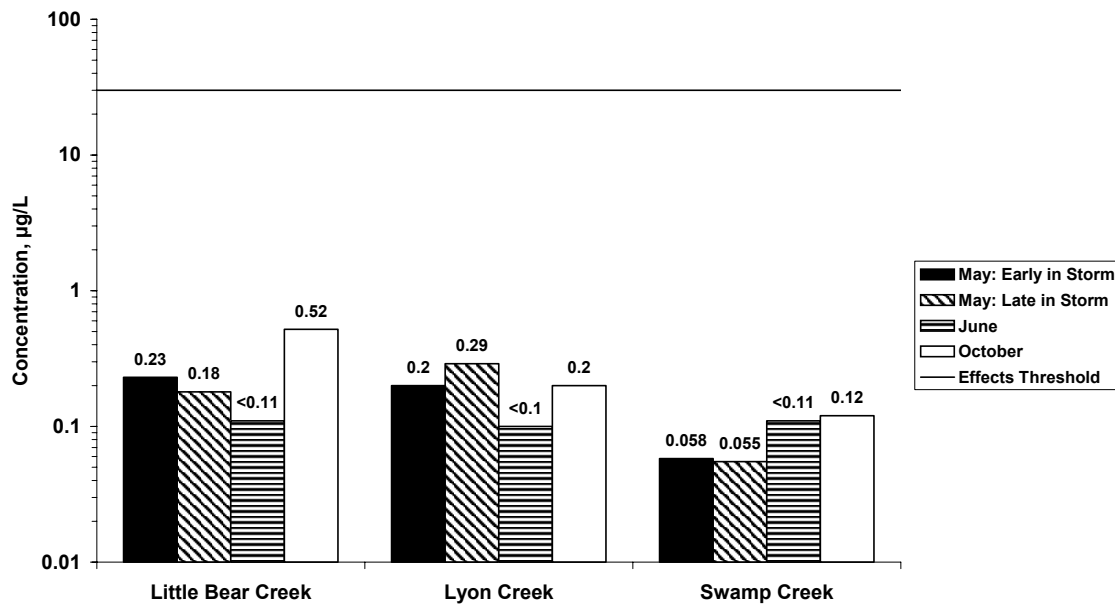


Figure 3-2. Concentrations of 4-Nitrophenol in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

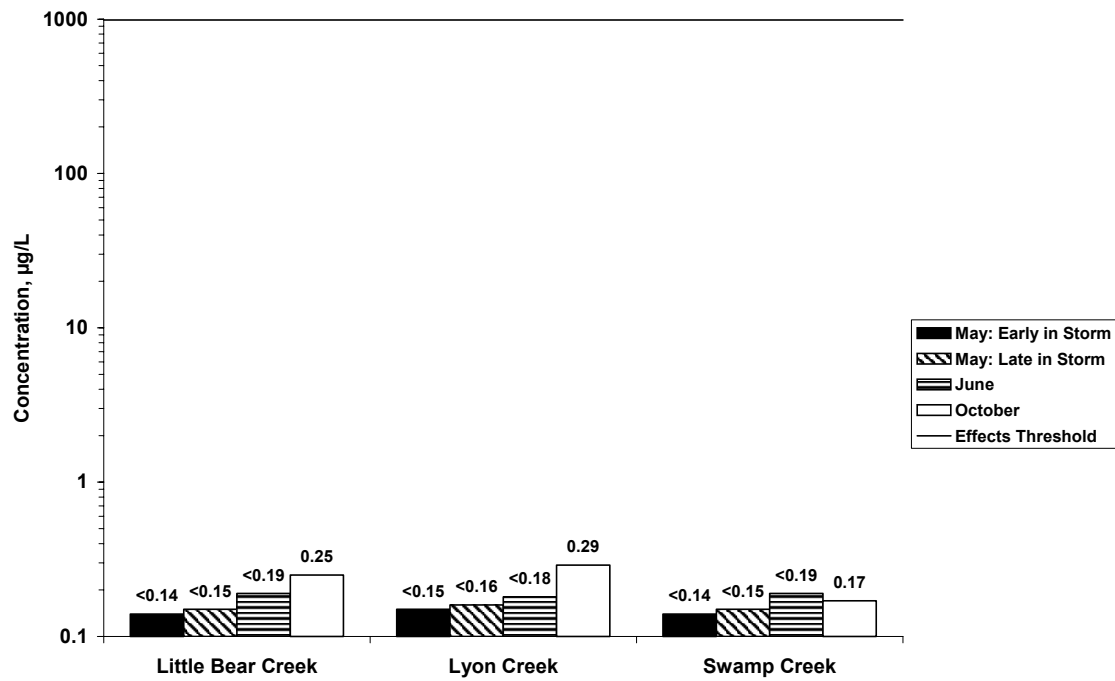


Figure 3-3. Concentrations of Atrazine in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

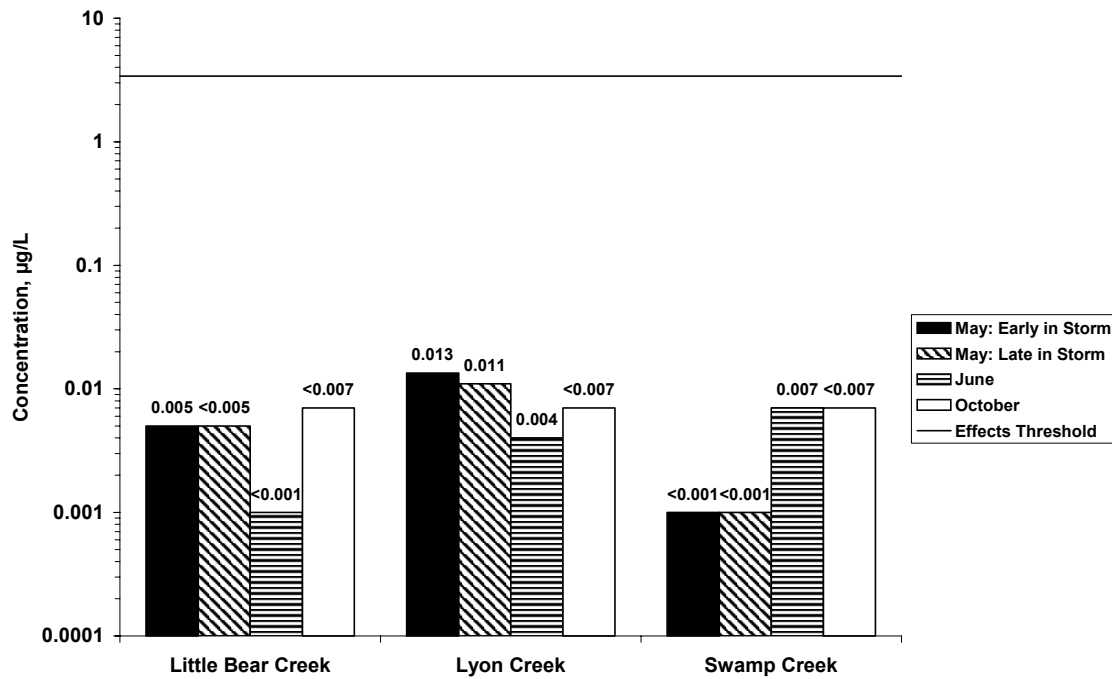


Figure 3-4. Concentrations of Bromacil in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

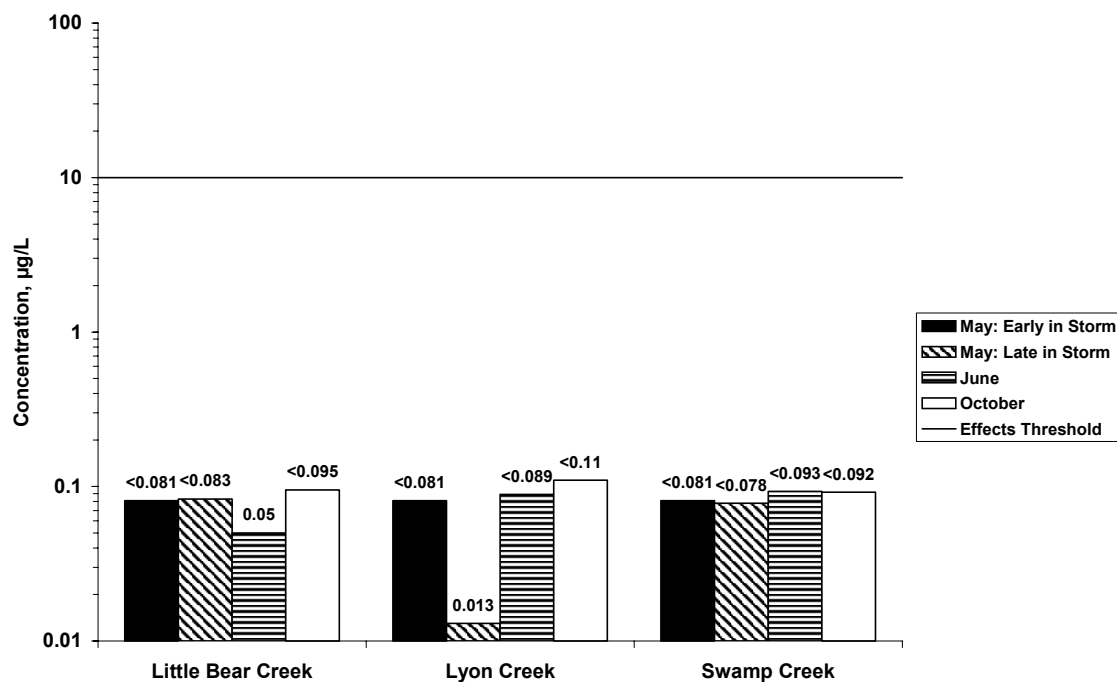


Figure 3-5. Concentrations of Carbaryl in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

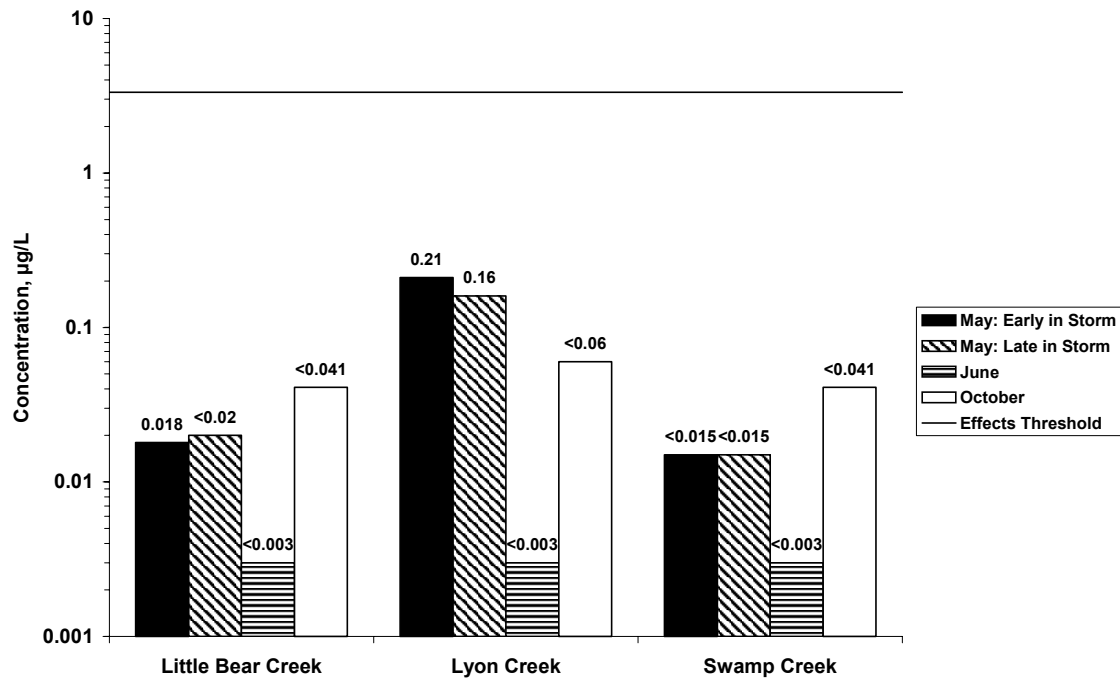


Figure 3-6. Concentrations of Chlorpyrifos in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

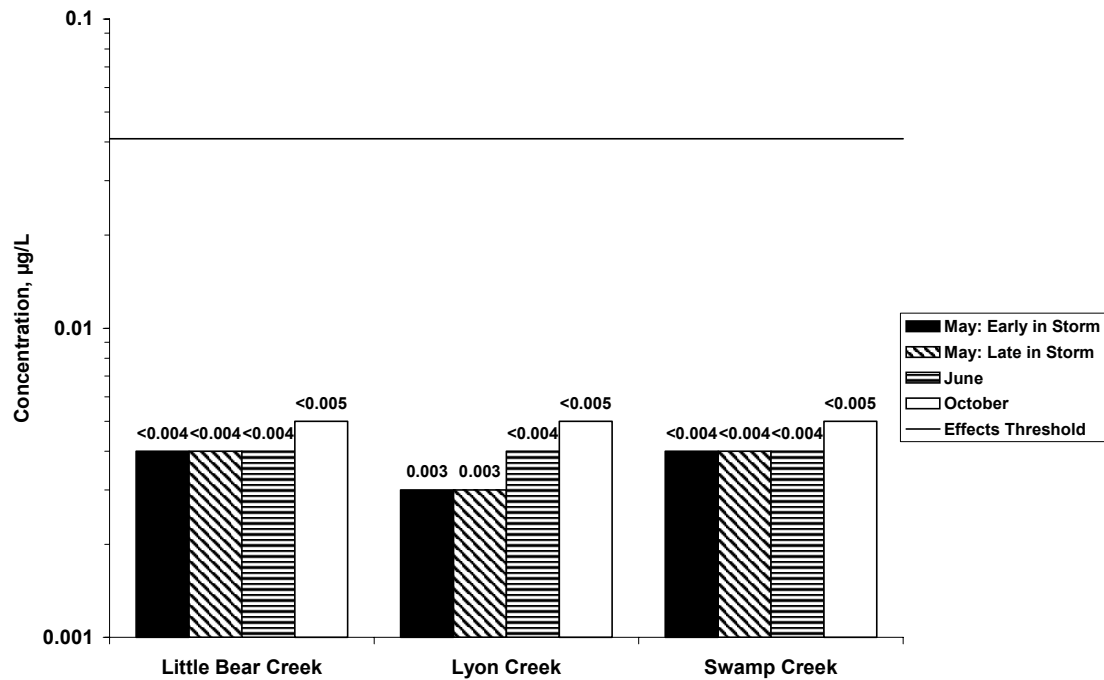


Figure 3-7. Concentrations of Desethylatrazine in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

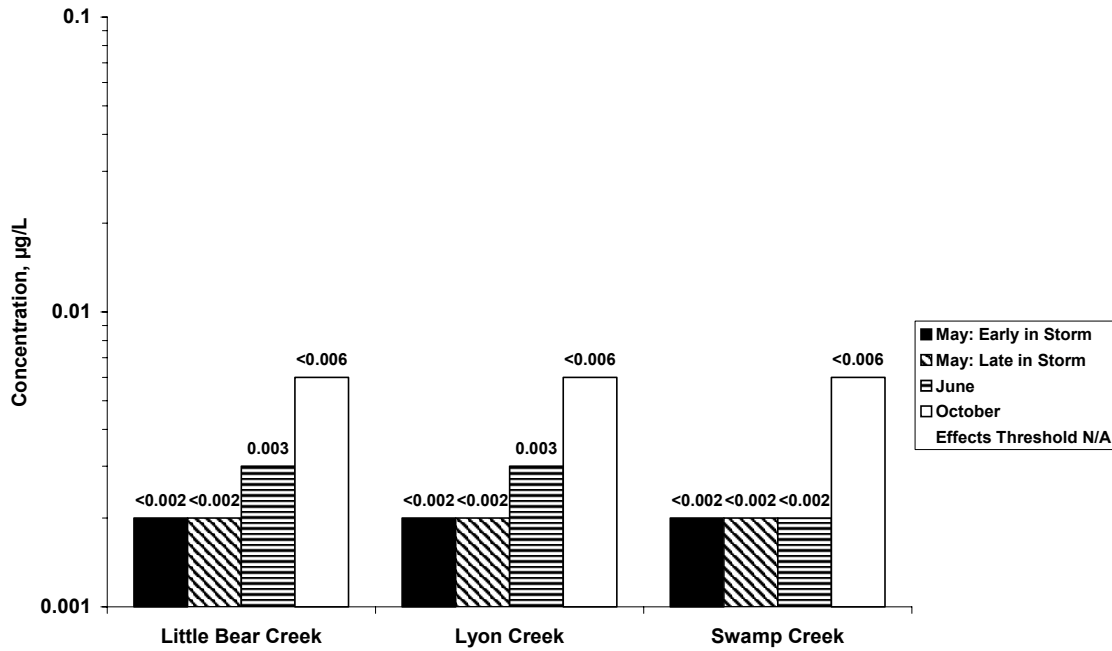


Figure 3-8. Concentrations of Diazinon in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

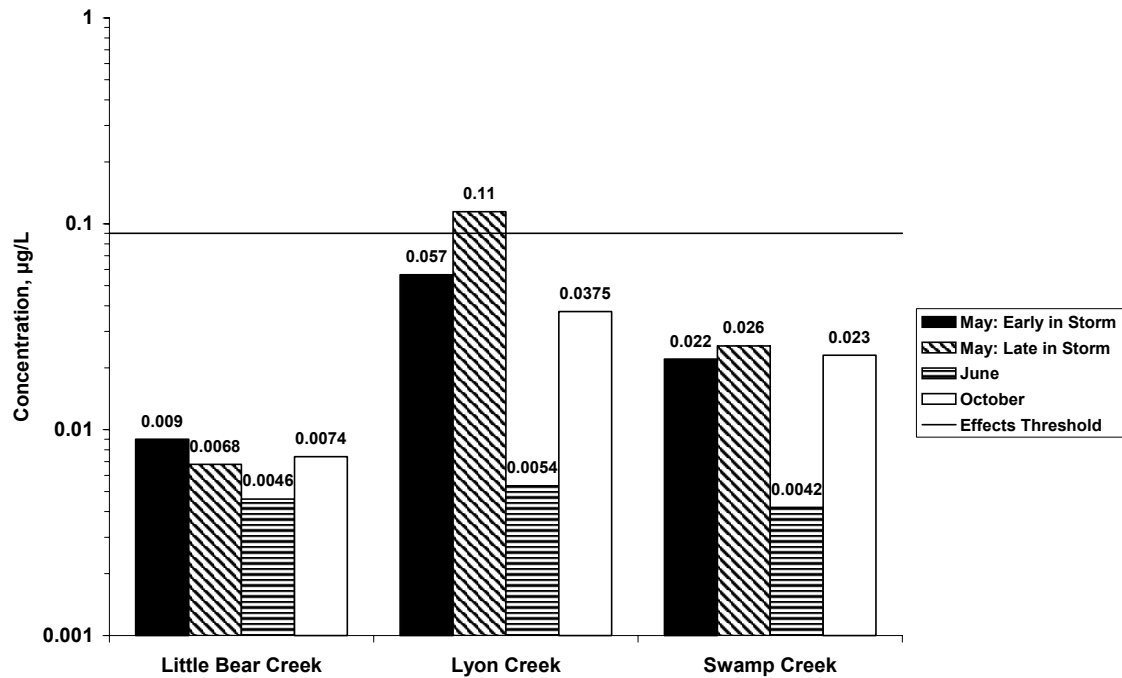


Figure 3-9. Concentrations of Dicamba in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

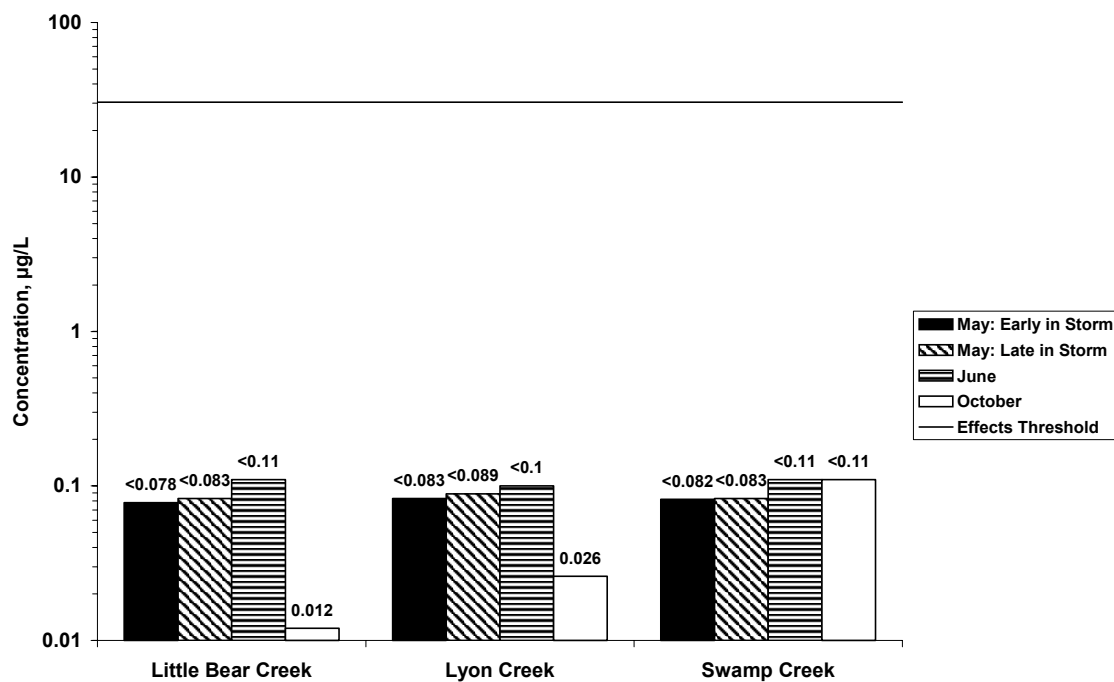


Figure 3-10. Concentrations of Dichlobenil in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

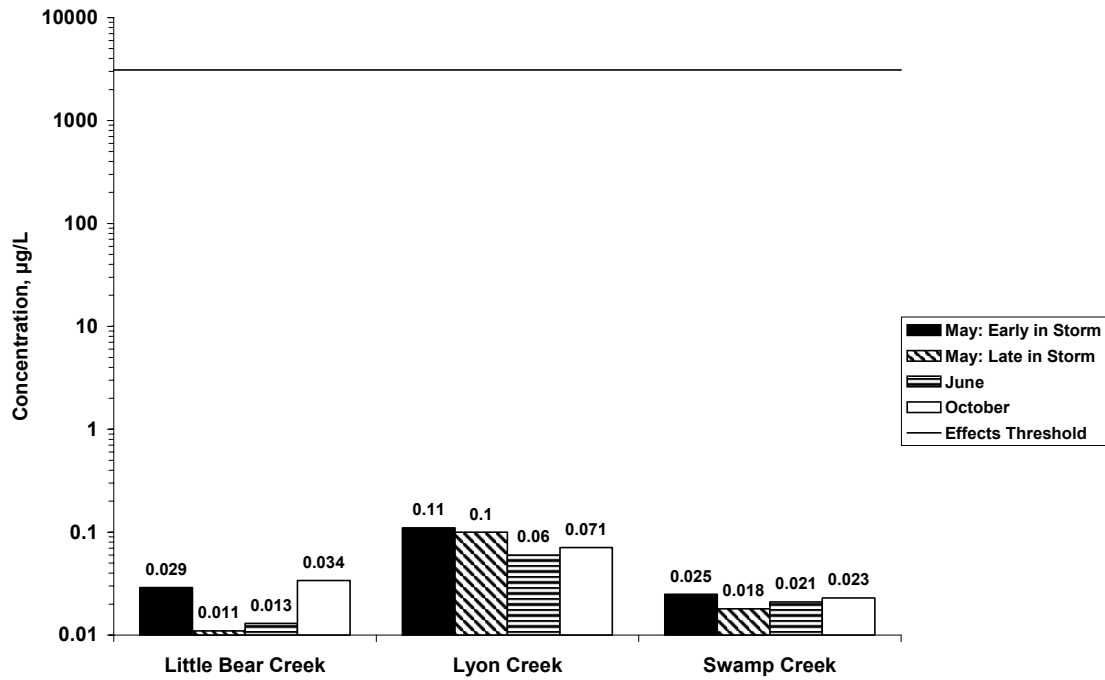


Figure 3-11. Concentrations of Malathion in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

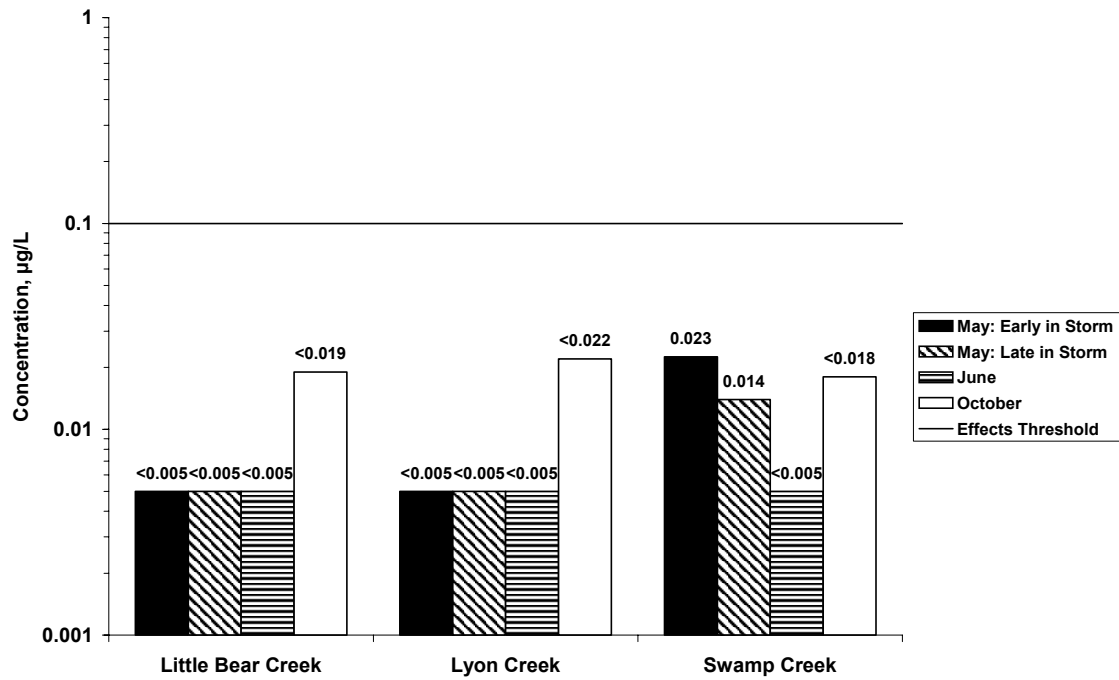


Figure 3-12. Concentrations of MCPA in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

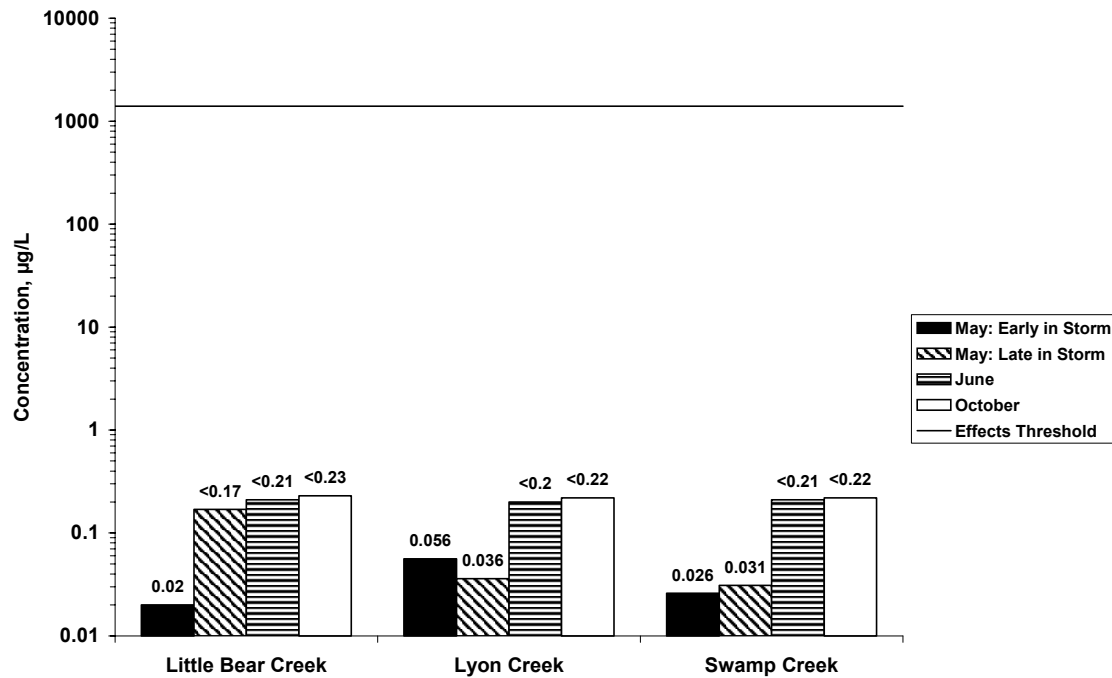


Figure 3-13. Concentrations of MCP P in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

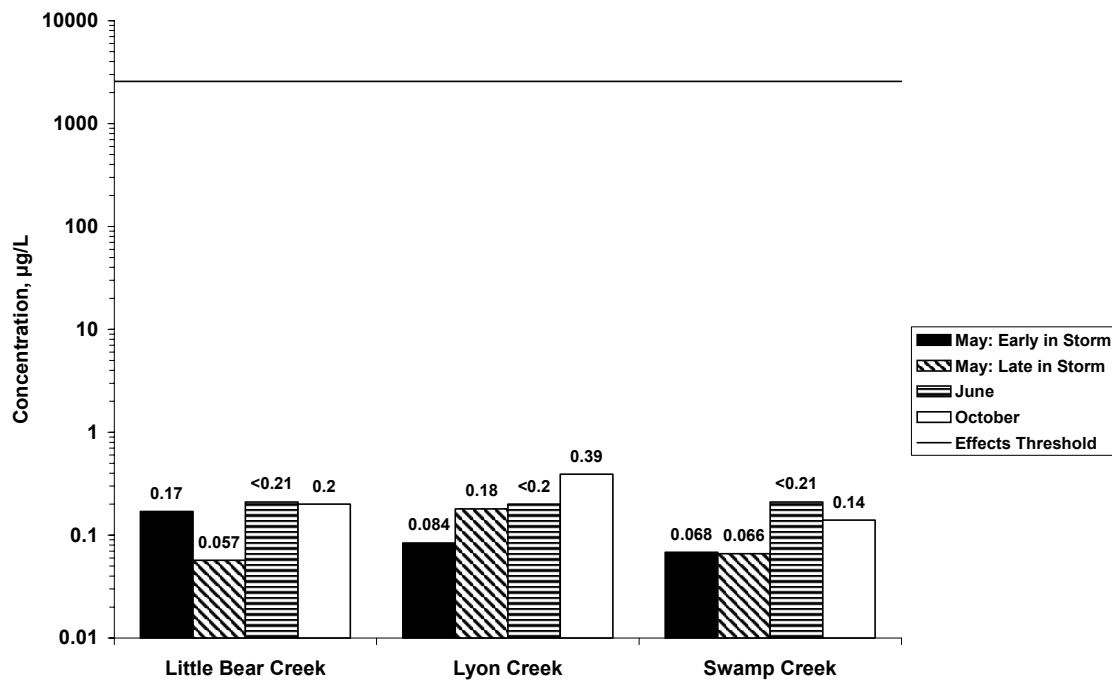


Figure 3-14. Concentrations of Pentachlorophenol in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

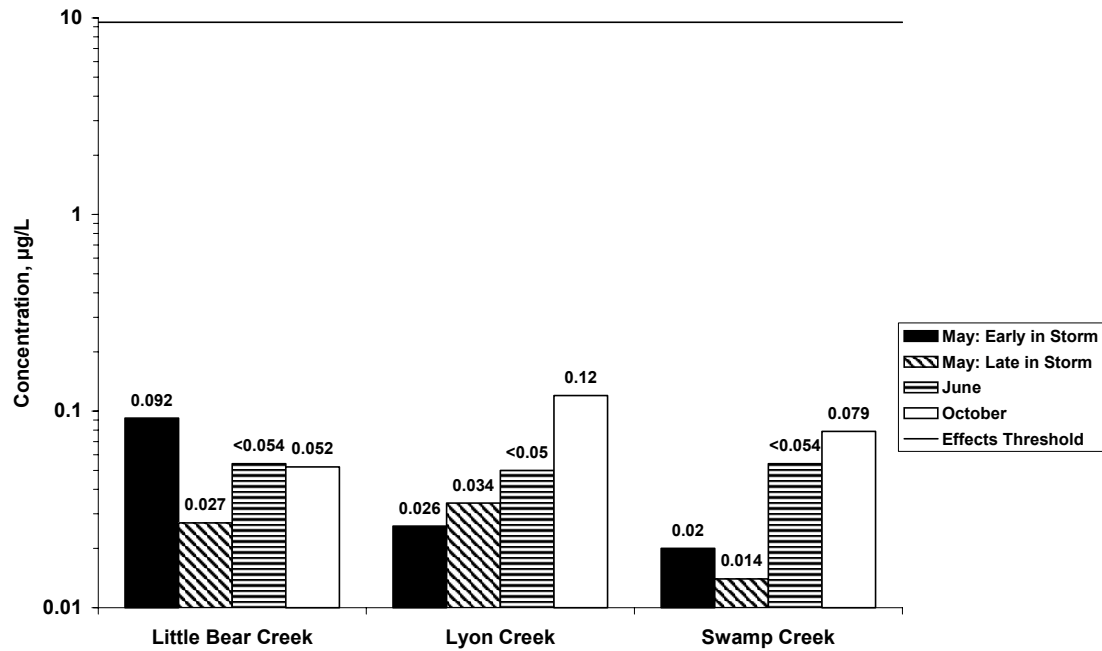


Figure 3-15. Concentrations of Prometon in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

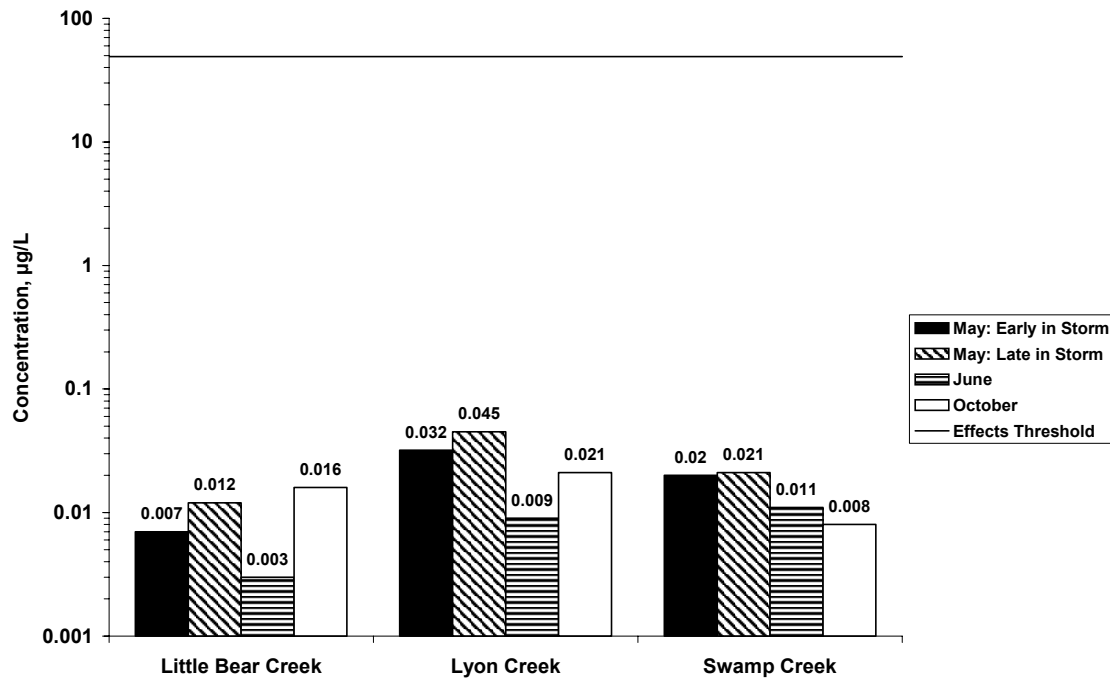


Figure 3-16. Concentrations of Simazine in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

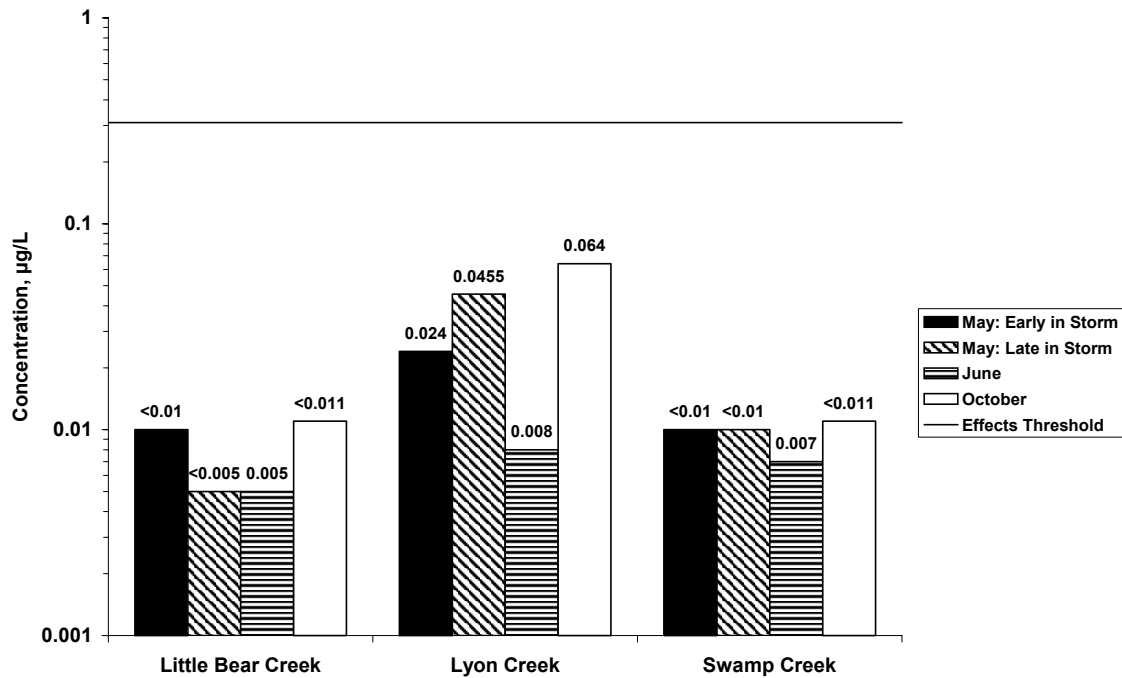


Figure 3-17. Concentrations of Tebuthiuron in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

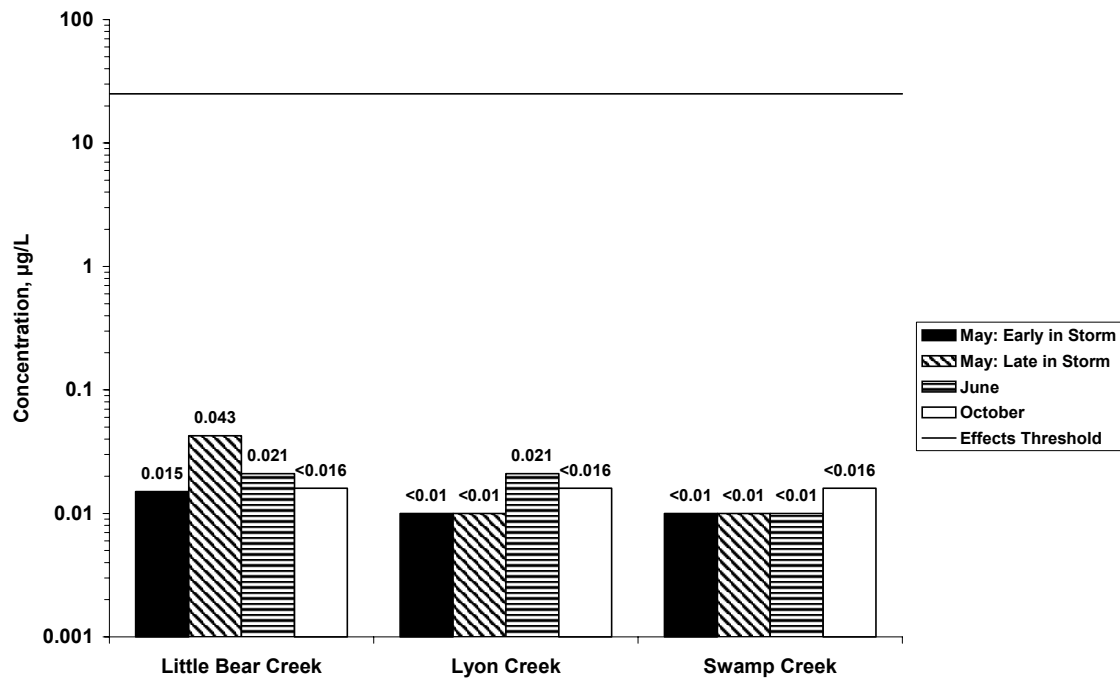


Figure 3-18. Concentrations of Trichlorpyr in Lyon, Little Bear, and Swamp Creeks During Sampling Periods

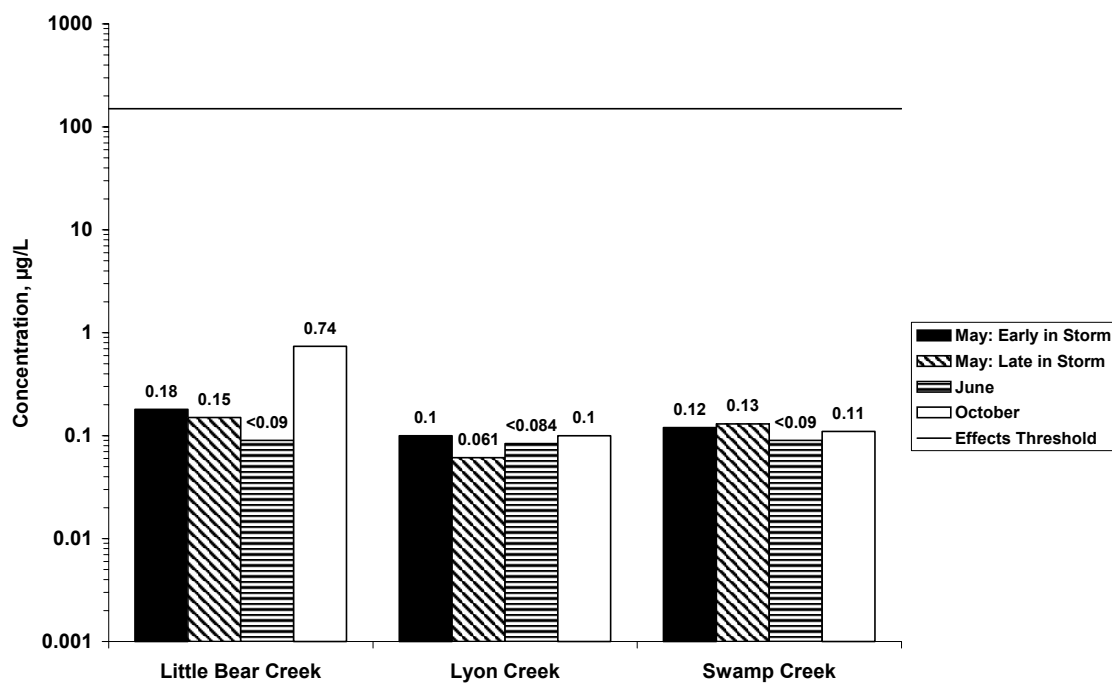
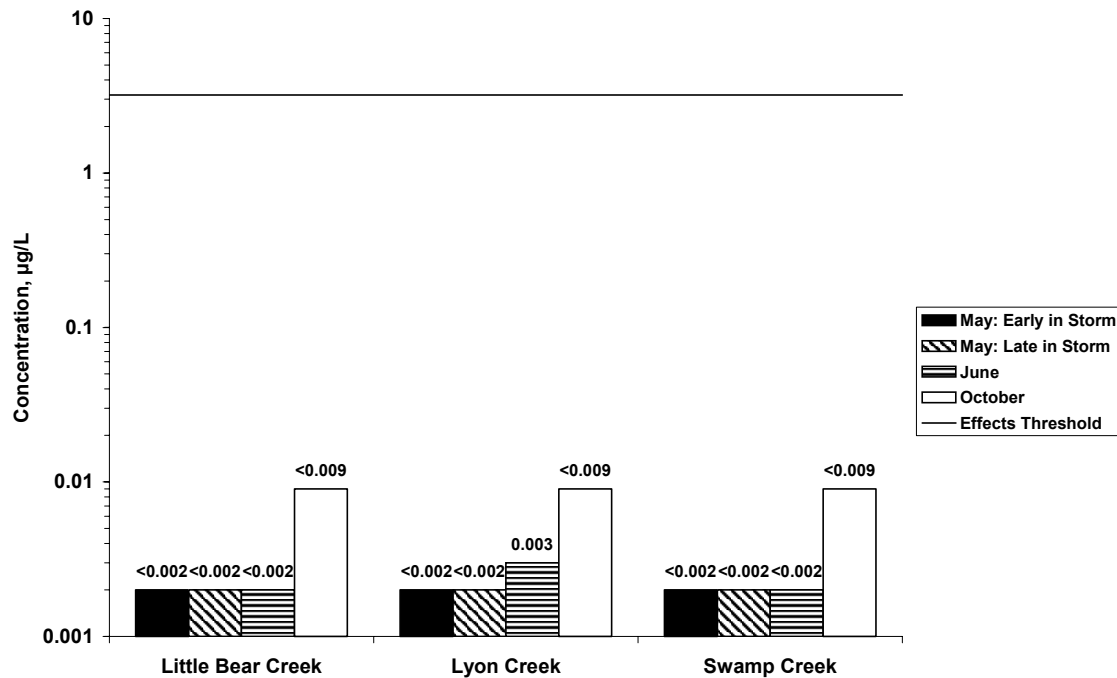


Figure 3-19. Concentrations of Trifluralin in Lyon, Little Bear, and Swamp Creeks During Sampling Periods



3.1.2. Metals

Measurement of total recoverable metal (TRM) concentrations includes some fraction of the metal that is bound to suspended solids or is strongly complexed with organic matter or other ligands and is not available to bind to gill receptor sites. Therefore, water quality standards for most divalent metals are based on the dissolved fraction of the metal, rather than the TRM concentration, as it more closely approximates the metal's bioavailable⁴ fraction (Prothro 1993; USEPA 1993). Effects thresholds for metals can be found in King County (2002). It should be noted that metals bound to suspended solids may settle and contribute to sediment metal loads. These sediment-associated metals may be incidentally ingested by water column organisms or be accumulated by benthic organisms and enter into the food chain. However, evaluation of sediment and dietary exposure pathways is beyond the scope of this report.

Of the metals detected in 2000 (Table 3-1), only one, aluminum, exceeded the effects threshold in the study creeks (by a factor of 1.9). This exceedance occurred in the June sample collected from Little Bear Creek. In water collected from the Sammamish River Irrigation Return, the aluminum concentration also exceeded the effects thresholds (by a factor of 38). A comparison of the remaining metal concentrations to their respective thresholds is presented in Appendix E. As for pesticides, HQs for all metals are provided in Appendix E.

3.2. Toxicity test Results

Toxicity test results for all streams and test species are summarized in Table 3-4. The table notes whether statistically significant ($p < 0.05$) effects were observed in the test streams when compared to the reference stream (Rock Creek). As summarized above, the endpoints evaluated were reproduction and survival for *C. dubia*, growth (cell count) for *S. capricornutum*, and growth (dry weight) for *L. minor*. The detailed results for each toxicity test are provided in Appendix F. The following sections summarize these results.

⁴ Bioavailability is the degree to which a contaminant in a potential source is free for uptake (movement into or onto an organism) (Hamelink et al. 1994).

Table 3-4. Summary of Toxicity test Results for 2000

Location	Season	<i>C. dubia</i>		<i>S. capricornutum</i>		<i>L. minor</i> ¹
		Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
Lyon	May: early in storm	-	NT	-	Sig	Sig
	May: late in storm	-	-	-	-	-
	June	-	-	Sig	-	Sig
	October	-	-	Sig	-	-
Little Bear	May: early in storm	-	NT	Sig	-	-
	May: late in storm	-	-	Sig	-	-
	June	-	-	Sig	-	Sig
	October	-	-	Sig	-	-
Swamp	May: early in storm	-	NT	-	-	Sig
	May: late in storm	-	-	-	-	Sig
	June	-	Sig	Sig	-	Sig
	October	-	-	Sig	-	-
Sammamish Irrigation	September	Sig	Sig	Sig	-	-

¹ Only unfiltered water was used in *L. minor* toxicity tests.

- = Not significantly different than reference site.

NT = Not tested.

Sig = Significantly less than reference site (p<0.05).

3.2.1. *Ceriodaphnia dubia*

C. dubia reproduction in unfiltered samples from the three urban streams was not significantly reduced compared to the reference site. A significant reduction in reproduction, however, was observed in the filtered sample collected from Swamp Creek in June (see Table 3-4). This observation is somewhat unexpected because filtration of the water sample removes constituents in the water sample. Theoretically, filtration removes chemicals bound to particulates greater than 0.45 µm, but concentrations of dissolved chemicals in the filtered and unfiltered samples should be the same. Accordingly, the observed reduction in reproduction in the filtered sample may not be chemical related. Furthermore, none of the pesticide concentrations in the June Swamp Creek sample exceeded their respective effects thresholds (see Section 3.1).

Significant toxicity to *C. dubia* (i.e., decreased survival and reproduction) was also observed in both unfiltered and filtered samples from the Sammamish River Irrigation Return collected in September. Based on the comparison of pesticide concentrations to effects thresholds, the source of this toxicity may have been diazinon, as the concentration exceeded the effects threshold. In addition, *C. dubia* is among the most sensitive species to diazinon (USEPA 2000).

A consistent trend in *C. dubia* reproduction was not observed in samples collected early and late in the May 2000 storm (Figure 3-20). *C. dubia* reproduction was significantly greater ($p < 0.05$) in samples collected late in the storm for Lyon Creek and Swamp Creek, and lower (although not significantly) late in the storm for Little Bear Creek. Although none of the observed toxicity in unfiltered samples was significant, the results for Lyon Creek and Swamp Creek suggest pesticide exposure may have been highest in the initial runoff, although this is not strongly supported by the chemistry data (Section 3.2). Differences in toxicity test results could be attributed to a number of other factors, including non-chemical stressors and random variability.

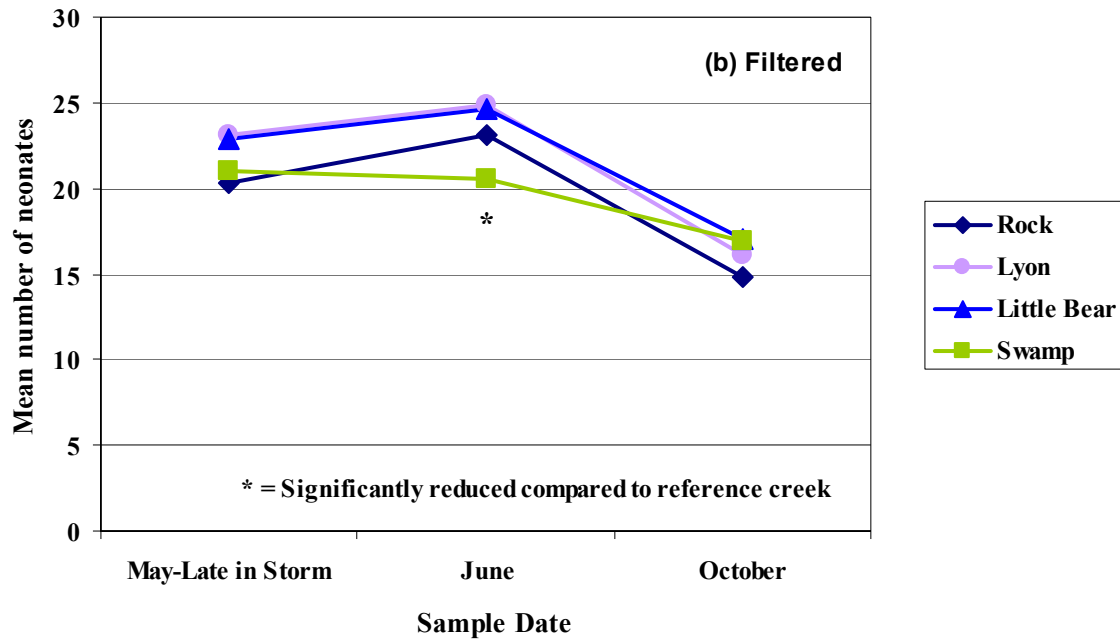
3.2.2. *Selenastrum capricornutum*

Growth of *S. capricornutum* was significantly reduced in 9 of 13 unfiltered creek samples, but only once in the filtered samples (see Table 3-4). The general absence of toxicity in the filtered samples suggests that the significant growth reduction observed in many of the unfiltered samples was not caused by dissolved chemicals. It is also unlikely that the observed growth effects are due to particulate-bound chemicals, as none of the metals or pesticides analyzed were ever detected at concentrations above their effects thresholds, with the exception of aluminum in two samples and diazinon in one sample.

To investigate the possibility of additive effects of pesticides, ratios of detected pesticide concentrations to effects thresholds were summed. The sum of these ratios exceeded 1.0 for the early (1.3) and late (1.6) spring storm samples from Lyon Creek. However, the pesticide contributing the most to the total summed ratio was diazinon, for which the effects threshold is driven by sensitive invertebrates (algae are an order of magnitude less sensitive). When only the sum of the detected herbicide ratios was calculated for each stream, the values were all below 1.0. Additionally, no relationship was found between the concentration of detected metals and growth of *S. capricornutum*.

Some non-chemical factors were investigated to explain the toxicity test results, including reduced light penetration or abrasion resulting from suspended particulates and competition for nutrients from indigenous algae in the creek samples. The possibility of a non-chemical factor influencing *Selenastrum* growth is also supported by reference site (Rock Creek) data, for which the same pattern was observed. In fact, growth in all unfiltered stream samples collected in spring 2000, including Rock Creek, was significantly reduced compared to the algal assay medium (AAM) in-house control. This last observation also suggests that the growth reduction observed in many of the unfiltered creek samples is not a function of laboratory conditions or methods.

Figure 3-20. Mean *C. dubia* Reproduction in (a) Unfiltered and (b) Filtered Stream Samples



The potential influence of TSS on the observed growth reduction in *S. capricornutum* was evaluated using TSS and turbidity data for the creek samples collected in 2000 (Table 3-8). There were no temporally consistent trends in TSS levels between urban creeks, although TSS was generally elevated in the storm samples (May, October) compared to the baseflow (June) sample. Although a consistent relationship between TSS and cell counts is not observed between creeks, within a given creek mean cell counts tended to decrease with increasing TSS concentration. Note, however, the Little Bear Creek sample with the highest TSS had the highest number of cell counts. Thus, despite the data generally supporting that TSS may be responsible for reduced algal growth, this was not always the case and suggests that other factors may be contributing to algal growth reduction. A study conducted by Andersen (2002) supported that factors other than TSS or turbidity in test creeks were responsible for the growth reduction in *S. capricornutum*. She observed that *S. capricornutum* growth was only impacted by turbidity once it reached 240 nephelometric turbidity units (NTU), which is over 30 times higher than the highest turbidity level measured in the creek samples.

Table 3-8. Total Suspended Solids (TSS) Concentrations in Stream Samples

Sample Site	Date	TSS (mg/L)	Turbidity (NTU)	Visual Observations
Lyon Creek	May (early)	82	-	Turbid; small particulates
	May (late)	30	-	Turbid; small particulates
	June	32	-	Clear; large plant debris and sediment particles
	October	172	86.1	Gold tint; particulates
Little Bear Creek	May (early)	30	-	Turbid; fine to small particulates
	May (late)	32	-	Turbid; fine to small particulates
	June	12	-	Slight gold tone; some floc
	October	38	20.5	Clear; some settled particulates
Swamp Creek	May (early)	22	-	Turbid; small particulates
	May (late)	33	-	Turbid; small particulates
	June	5	-	Slight gold tone; some floc
	October	21	11.4	Gold tint; cloudy
Rock Creek	May	-	-	-
	June	-	-	Clear, some floc
	October	-	1.07	Clear

NTU = Nephelometric Turbidity Units

- = Not available

The reduction in *S. capricornutum* growth could also be due to indigenous organisms present in the unfiltered samples. For example, indigenous algae could compete for nutrients with the test algae (observations of indigenous algae in the toxicity test samples were noted). To evaluate this hypothesis further, the initial and final concentrations of ortho-phosphate (PO₄-P) and nitrate in the urban stream and reference stream samples were measured in the June and October samples (Table 3-9). The N:P for removal was higher than the theoretical 16:1 (as elements) in water from all the sites. This indicates that sufficient levels of nutrients were present for growth, and that competition for nutrients was probably not a factor in the growth reduction observed in the filtered samples.

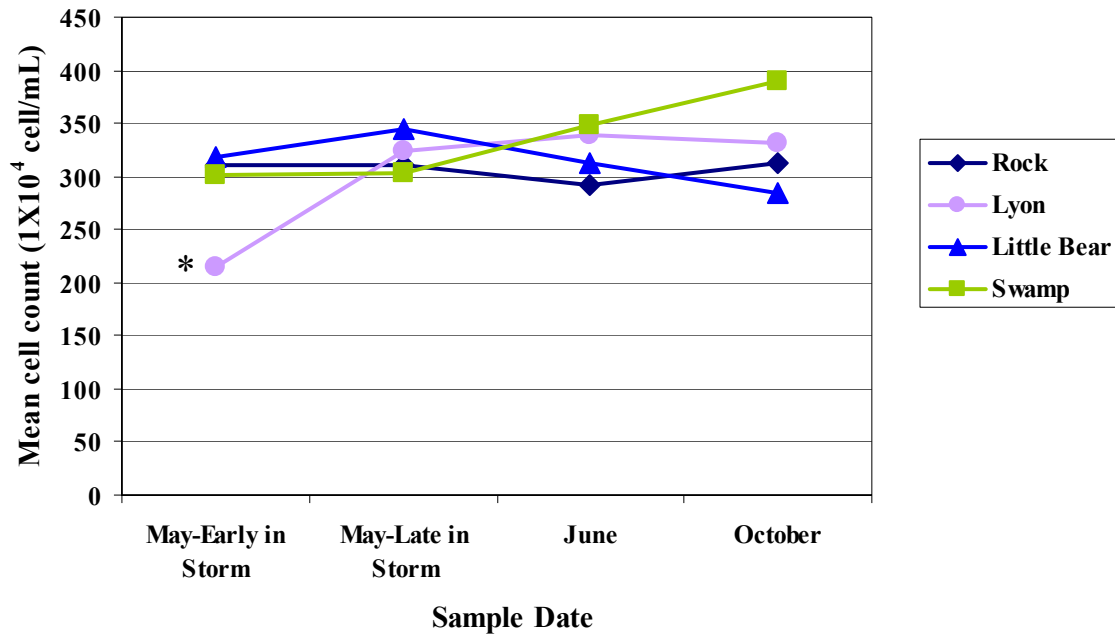
Overall, it does not appear that TSS, turbidity, or competition for nutrients by indigenous algae are responsible for the *S. capricornutum* growth reductions observed in the toxicity tests of unfiltered samples. To further evaluate potential influences of indigenous organisms in the unfiltered samples, the 2002 small streams study is planning on conducting *S. capricornutum* toxicity tests on unfiltered samples that have been sterilized (as well as non-sterilized filtered and unfiltered samples).

Table 3-9. Initial and Final Nutrient (orthoP and NO₂ +NO₃) Levels and Nutrient Removal from Filtered Samples at the End of the 4-Day Test

Sample Site	Date	OrthoP (mg/L)			NO ₂ + NO ₃ (mg/L)			Removal N:P
		Initial	Final	Removal	Initial	Final	Removal	
Rock Creek	June	0.190	0.003	0.187	4.36	2.36	2.00	24:1
Lyon Creek	June	0.221	0.002	0.219	5.45	0.73	4.72	48:1
Little Bear Creek	June	0.208	0.004	0.204	4.89	1.23	3.66	40:1
Swamp Creek	June	0.234	0.003	0.231	5.23	1.91	3.32	32:1
Rock Creek	October	0.189	0.003	0.186	4.25	1.71	2.54	30:1
Lyon Creek	October	0.220	0.004	0.216	5.11	2.11	3.00	31:1
Little Bear Creek	October	0.224	0.003	0.221	4.94	1.78	3.16	32:1
Swamp Creek	October	0.224	0.002	0.223	5.03	1.62	3.41	35:1

Like the *C. dubia* toxicity test results, consistent trends within an individual storm or between seasons were not observed in all streams. In general, *S. capricornutum* growth was similar in the stream samples collected early and late in the May storm event (Figure 3-21). A statistically significant difference ($p < 0.05$) in growth was only observed in the Lyon Creek samples (both unfiltered and filtered). In the unfiltered Lyon Creek sample, *S. capricornutum* growth was significantly lower early in the May storm, while the opposite was observed in the filtered sample. *S. capricornutum* growth was significantly different ($p < 0.05$) between May (late in storm) and October in unfiltered samples collected from Lyon and Little Bear Creeks and in the filtered sample collected from Little Bear Creek. Growth in the unfiltered Lyon and Little Bear Creek samples decreased and increased in the October sample, respectively, while growth in the Little Bear Creek filtered sample decreased in October compared to May.

Figure 3-21. Mean *S. capricornutum* Growth in (a) Unfiltered and (b) Filtered Stream Samples



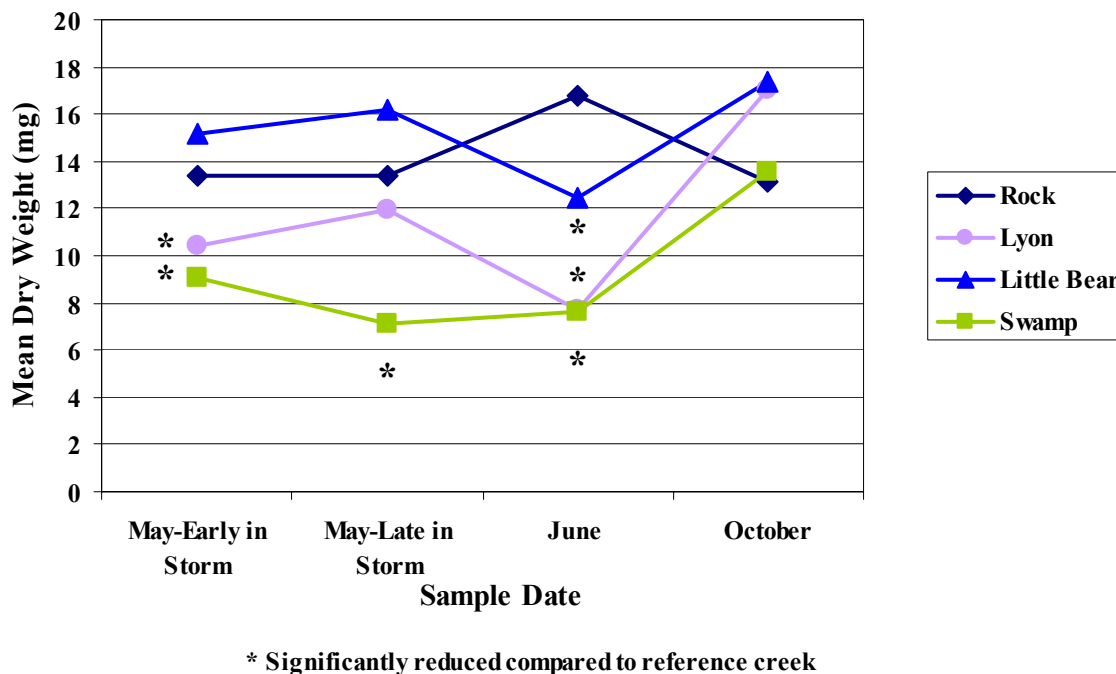
* = Significantly reduced compared to reference creek

3.2.3. *Lemna minor*

L. minor growth was only assessed in unfiltered stream samples because suspended solids are not expected to affect *L. minor* as it is a free-floating aquatic plant. Significantly reduced growth compared to Rock Creek was observed in six of 13 samples (Figure 3-22). Growth was significantly reduced in Lyon and Swamp Creeks in at least one of the spring storm samples, and in June samples from all three streams. Without results for filtered samples, it is not possible to determine if the observed growth reduction was a function of dissolved chemicals. Using effects threshold comparisons, no relationships were observed between the concentration of pesticides or metals detected and growth of *L. minor*. Like the *S. capricornutum* results, it is possible other unknown factors are responsible for the observed growth reductions.

Based on the samples collected during the May storm event, growth was significantly reduced ($p < 0.05$) in the sample collected early in the storm compared to the sample collected late in the storm. This is consistent with the May toxicity test results observed for *S. capricornutum*. In comparing *L. minor* growth between the May (late in storm) and October storms, growth was significantly lower ($p < 0.05$) in the May samples from Lyon and Swamp Creeks.

Figure 3-22. Mean *L. minor* Growth in Unfiltered Stream Samples



4. SUMMARY AND CONCLUSIONS

4.1. Summary of Results

This study was designed to provide field and laboratory data to address three primary questions:

1) Are pesticides present in Lyon, Little Bear, and Swamp Creeks at detectable levels?

A total of 18, 15, and 12 pesticides were detected in Lyon, Little Bear, and Swamp Creeks, respectively. The pesticides most frequently detected during storm events included the insecticide diazinon, the herbicides 2,4-D, dichlobenil, MCPP, prometon, and trichlopyr, and the insecticide/fungicide pentachlorophenol. These pesticides were either not detected, or detected at lower levels, in the baseflow (June) samples, suggesting that storm water runoff is a significant source of pesticides to the suburban streams evaluated.

2) Do water samples from the suburban creeks adversely affect *C. dubia*, *S. capricornutum*, and *L. minor*?

Toxicity tests were conducted with *C. dubia* and *S. capricornutum* using both unfiltered and filtered samples, while *L. minor* toxicity tests were conducted using only unfiltered samples. Toxicity was observed in 19 of 62 separate toxicity tests using all three test species in all test creeks during the study. Unfiltered samples adversely affected⁵ growth of *S. capricornutum* and *L. minor* in a minimum of one sample from each creek; no unfiltered samples adversely affected reproduction or survival of *C. dubia*. Using filtered water, only one sample adversely affected reproduction or survival of *C. dubia* (October, Swamp Creek) and *S. capricornutum* growth (May [early], Lyon Creek). Finally, unfiltered samples from the 124th Street Sammamish River Irrigation Return were found to adversely affect *C. dubia* reproduction or survival and *S. capricornutum* growth, and filtered samples were found to adversely affect *C. dubia* reproduction or survival.

3) How does time of sample collection (seasonally or within an individual storm) influence contaminant levels or adverse effects to test organisms?

In general, fewer pesticides were detected under baseflow conditions compared to storm flows. In addition, concentrations of detected pesticides were lower under baseflow conditions. However, a consistent temporal pattern was not observed within the May storm event or between the May and October storm events. Within an individual creek, concentrations of detected pesticides in May were not consistently higher or lower early in the storm compared to late in the storm. In addition, between creeks, concentrations of some pesticides increased from May to October, while others decreased.

⁵ An adverse effect is defined as a statistically significant ($p < 0.05$) response compared to the reference creek.

No consistent patterns in toxicity test results were observed within the individual May storm or between the May and October storms. In filtered samples, *C. dubia* reproduction was significantly ($p < 0.05$) reduced in the Lyon, Little Bear, and Swamp Creek samples collected in October compared to May. However, *S. capricornutum* growth was reduced in May, compared to October, in Little Bear and Swamp Creeks.

4.2. Summary and Conclusions

This study documented increases in the number and concentration of pesticides in suburban creeks during storm events. Also, toxicity tests demonstrated that some samples adversely affected test organisms when the response was compared to a reference site. Effects threshold concentrations were exceeded twice in the 13 samples that were analyzed for pesticides. The first exceedance was for diazinon in Lyon creek in the sample collected late in the spring storm event. However, no corresponding toxicity was observed. The second was also for diazinon in the 124th Street Sammamish River tributary. In this case, toxicity was observed for two of the three test species, which suggests that diazinon was the cause. Effects thresholds were not exceeded in the remainder of cases where toxicity was observed, leaving the cause of observed toxicity uncertain.

The first step in understanding the ecological significance of the pesticide concentrations is to identify whether a causal link exists between the chemistry and toxicity test results. The available data may be used as evidence to indicate whether pesticides are resulting in adverse effects to the test organisms, but are not conclusive because any number of stressors could be responsible for the observed effects. For example, the reduction in effects to *Selenastrum* in filtered samples suggests that other organisms in the sample, particulates, or compounds associated with the particulates are a source of stress to the algae. In addition, other stressors, such as non-pesticide organic chemicals, were not analyzed.

To truly elucidate whether pesticides are the cause of the observed toxicity, a toxicity identification evaluation (TIE) would be required. A TIE uses a series of sample manipulations to identify the class of compound responsible for the observed toxicity observed in a sample. Such an approach has been used successfully in samples from the Sacramento-San Joaquin River Delta to identify organophosphate and carbamate pesticides as the source of toxicity to *C. dubia* (Werner et al. 2000).

Another issue that may have influenced the interpretation of toxicity test results is the applicability of the reference creek (Rock Creek) to Lyon, Little Bear, and Swamp Creeks. Rock Creek is far from the suburban test creeks, at a higher elevation, and potentially has quite different natural inputs, water quality characteristics, and invertebrate populations. These differences may potentially influence the performance of test organisms and toxicity test results. Interpretation of toxicity test results is also compounded by the observation that *S. capricornutum* growth in the unfiltered sample from Rock Creek collected in spring 2000 did not meet the control criteria of 1.0×10^6 cells per mL. Growth in the Rock Creek sample was also significantly reduced compared to in-house controls using AAM. Thus, it is clear that characteristics of the natural waters may substantially influence test organism performance and mask the source of any potential anthropogenically generated stressors.

To further evaluate whether pesticides are causing adverse effects to aquatic biota during storm events and posing a risk to aquatic communities, future studies should focus on determining

causality. In terms of toxicity, this would require conducting TIEs to elucidate the cause of any observed toxicity. Assessing whether aquatic communities are at risk from pesticides will require an evaluation of all potential stressor sources in the creek subbasins. For example, *S. capricornutum* testing in 2002 will be conducted using filtered, unfiltered, and sterilized unfiltered stream samples. This will help determine if reduced growth is due to toxicants associated with particulate matter or stress from competition with other algae for nutrients or predation by organisms in the unfiltered stream water. This and other stressor sources will be evaluated in the SWAMP risk assessment. The combination of TIE results and a risk characterization of all likely stressors to a creek community will provide the strongest evidence of whether pesticides from storm events are posing an unacceptable risk to suburban creeks.

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APPENDIX A:
SMALL STREAM TOXICITY STUDY

PROJECT SAMPLING AND ANALYSIS PLAN
SMALL STREAMS TOXICITY STUDY

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Approved By

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1.0 PROJECT DESCRIPTION

Background

The United States Geological Survey (USGS) and the Washington Department of Ecology (Ecology) have been studying the ambient distribution of pesticides in the Puget Sound Region for much of this decade under the National Water Quality Assessment Program (NAWQA). Much of this work has involved storm sampling, in effect monitoring current trends in non-point pollution. Initial findings focused subsequent efforts on small suburban streams. The highest number of pesticide detection's have occurred in the urban/suburban setting, particularly in watersheds with a high percentage of residential land use. This has led to the conclusion that chemicals from lawns and landscapes are consistently making their way into non-point run off.

In 1999 the Small Stream Study was primarily designed to answer three questions:

Question 1: Is toxicity¹ observed in small streams?

Answer Yes. Toxicity to the test species *Selenastrum capricornutum* was observed in the three test streams

Question 2: Is toxicity observed in small streams at different times of the year and under different hydrologic conditions?

Answer Yes. Toxicity to *S. capricornutum* was observed in test streams during three sampling events: spring and fall runoff and summer baseflow.

Question 3 To what extent can the observed toxicity be linked to pesticides or other contaminants that may be present in the streams?

Answer The 1999 study design enabled us to take an initial look at what might be causing toxicity observed in the study streams. It did not, however, provide a definitive answer to this question. We did learn that some of the observed toxicity is likely the result of exposure to a mixture of compounds including metals and pesticides. Based on our preliminary work, it appears that much of the observed toxicity was caused by exposure to particulate associated chemicals². To answer the question "What is causing the observed toxicity?" will require further study.

Currently, King County is evaluating the potential environmental impact of siting a new treatment plant in the North Lake Washington/Sammamish watershed. Of particular interest is the potential environmental impact of a freshwater discharge and use of reclaimed water (i.e., direct or indirect

¹ Toxicity as based on the effects observed in two test species; *Selenastrum capricornutum* and *Ceriodaphnia dubia*.

² Toxicity was significantly decreased when samples were filtered prior to testing.

discharge) on the Sammamish/Washington watershed. A clear understanding of current environmental conditions is critical to fully understand the environmental significance and potential effects such projects would have on the ecosystem, including threatened and endangered species.

2000 Study Questions

To thoroughly understand the current environmental conditions in the watershed, a better understanding of the toxicity observed in streams in 1999 is necessary. To obtain this information, a follow-up study for 2000 will be conducted to answer these questions:

- (1) What is the environmental significance of toxicity observed in 2000?
- (2) What is the general class of contaminant (e.g., metal, pesticide) likely causing the observed toxicity?
- (3) Additional assessments will be made on the relative difference in toxicity between samples taken early and late during the same storm and storms early and late in spring.

To better understand the environmental significance of toxicity information, sampling in 2000 will be conducted in streams where additional habitat and water quality data is available. Both Swamp and Little Bear Creeks have had habitat assessments, fisheries use assessments, and benthic taxonomy analysis completed. This information, along with the toxicity, pesticides, and metals data that will be collected in 2000, will enable staff to use a risk assessment approach to evaluate the environmental significance of the toxicity information.

To understand the general class of contaminant likely causing the observed toxicity, special toxicological manipulations will be used on samples exhibiting toxicity. This information will be used in a number of ways:

- to determine if a specific causal agent may be identified
- where to focus future investigative efforts
- to determine if best management practices will be useful in preventing toxicity and
- to begin to understand treatment objectives for a freshwater discharge and the use of reclaimed water in the watershed.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITY

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3.0 DATA QUALITY OBJECTIVES

The procedures and practices described in this Sampling and Analysis Plan are designed to generate data that will be useful to and will support decision making as discussed in the project description section. Critical elements of data quality objectives are discussed in this section. Procedures to attain these data quality objectives are discussed throughout this document.

An associated QA Plan has not been prepared for this project. However, additions such as data reporting have been made to this SAP to include some of the topics normally included in a project QA Plan.

Precision and Bias

Laboratory default QC procedures are sufficient for both the chemical testing and toxicity testing. Replicates, positive and negative control samples as per routine laboratory protocol are to be analyzed for this study. A reference site is included in each sampling event.

All organics (pesticides, herbicide and BNA) analyses are to include surrogate compounds. Some pesticide compounds are present on both the USGS and Ecology target lists, analytical replicate data will be available for these compounds. However, it should be pointed out that only USGS will filter pesticide samples prior to analysis.

One field replicate will be collected for metals and one field duplicate (field split) will be collected for total suspended solids and pesticides/herbicides during the early phases of the study, either the spring or summer sampling.

Elements of “clean hands” sampling will be employed to prevent contamination of samples. One field blank will be collected for metals analysis during each sampling event. One field blank will be collected for pesticides/herbicides during the first (Spring) sampling event. Metals results will be compared to water quality standards.

Representativeness

Sites to be sampled are not considered to represent all such sites in this region. Selected high bias sites have higher levels/and or more detection's of pesticides than other sites studied. A site with low previous detected levels of pesticides, a low bias site, has also been selected.

The timing of the sampling event is selected to enhance the probability of detecting pollutants and toxicity. Storm water samples will be collected as stream levels rise during the initial runoff from a storm event.

Pesticide, and total suspended solid samples will be collected using a technique which collects a representative grab sample. This technique composites a group of grab samples taken across a stream cross section. Toxicity and metals samples will be collected from a single high flow location within the stream. This is considered to approximate representative sampling techniques. It should be pointed out that for some parameters, such as the low levels metals analysis, the

likelihood of contamination from a multiple sample compositing technique far outweighs the possible advantages of obtaining a slightly more representative sample.

Comparability

Sampling technique is coordinated with USGS and employs the same technique as in previous studies for the toxicity and pesticide samples. Other parameters have not previously been sampled and tested.

Laboratories used for previous studies are to be used for this study as well. This enhances data comparability.

Completeness

Based on data usage, and the limited and focused nature of this study, all parameters are needed for each site. Analytical difficulties requiring dilution of the sample matrix and subsequent elevation of quantitation limits are to be relayed to the Project Manager, Dean Wilson. In this event, he will coordinate with other data users, George Perry and Jim Ebbert, to formulate a potential resolution.

Detection limits are not expected to vary significantly from those contained in the attachment to this SAP. However, detection limits are matrix dependent and although we do not anticipate that the practical quantitation limits will vary significantly from those stated in the method, the possibility does exist with a storm event. Hold times are to be achieved for all analyses.

4.0 SAMPLING PROCEDURES

Samples in 1998 showed higher levels of diazinon than 1999. Also, toxicity to *Ceriodaphnia* was observed in 1998 but not in 1999. Possible reasons are that 1998 samples were collected earlier in the storm event and the storm sampled occurred earlier in the spring when pesticide sales data showed highest sales. To assess if there are any differences in pesticide concentrations during the early part of a storm and the late part of the storm, we will collect two samples during each storm event. To assess if there are any differences between an early spring storm event and a later one, we will collect samples from two spring storm events.

Water from Rock Creek will be sampled during non-storm events for reference testing.

Sampling Matrix

Sampling Summary Table

Site	Early Spring Runoff		Late Spring Runoff		Early Fall Runoff
Sample Timing	Early in Hydrograph	Late in Hydrograph	Early in Hydrograph	Late in Hydrograph	Early in Hydrograph
Lyon Creek	Toxicity, Pesticides, Metals, TSS	Toxicity, Pesticides, Metals, TSS	Toxicity, Pesticides, Metals, TSS	Toxicity, Pesticides, Metals, TSS	Toxicity, Pesticides, Metals, TSS
Swamp Creek	Toxicity, Pesticides, Metals, TSS	Toxicity, Pesticides, Metals, TSS	Toxicity, Pesticides, Metals, TSS	Toxicity, Pesticides, Metals, TSS	Toxicity, Pesticides, Metals, TSS
Little Bear Creek	Toxicity, Pesticides, Metals, TSS	Toxicity, Pesticides, Metals, TSS	Toxicity, Pesticides, Metals, TSS	Toxicity, Pesticides, Metals, TSS	Toxicity, Pesticides, Metals, TSS

Additionally, one equipment field blank will be collected for pesticides and metals.

The first flush from the storms will be sampled using autosamplers. Once the storm begins, field crews will travel to the sampling locations, pick up the sample that was collected by the autosampler and collect a second sample using techniques described in the original sampling and analysis plan.

Storm criteria will be similar to sampling in 1999. Storm water target volume will again be in the range of 0.25 inches. An antecedent dry period of several days will be necessary. Ideally, a target storm will follow a dry sunny weekend, in which homeowners are most likely to be gardening and maintaining the landscape in residential areas. Dan Smith (King County) and Sandy Embrey (USGS) will consult prior to mobilization.

Filtration

Filtration will be conducted in the field for USGS Method 2010 as described below. Filters are to be stored frozen in glass jars until permission for disposal is granted by the project manager. Any filtering conducted for toxicity testing will be conducted by the aquatic toxicity laboratory. Filters may be discarded.

Field Blank. One (1) field blank will be collected for pesticide/herbicide testing. Clean water will be used in field blank collection. USGS Laboratory water will be drawn through the stream sampler (described above), into the sample bottles and then into the compositing carboy. The Teflon cone splitter will be used to split a sample aliquot into a sample bottle for blank testing.

Field Duplicate (Field Split). To assess the precision of the field sampling and analytical processes, one (1) field duplicate sample will be collected at a given site for pesticide/herbicide and TSS analysis.

Equipment Blank. To assess potential contamination from auto samplers, one equipment blank will be collected and analyzed.

Field Quality Control Samples

Parameter	Field QC Sample Type	Frequency
Metals, Total & Dissolved (includes Hg)	Field Blank	Once / Event
Metals, Total & Dissolved (includes Hg)	Field Equipment Blank (autosampler)	Once / Project
Pesticides / Herbicides	Field Equipment Blank (autosampler)	Once / Project
Metals, Total & Dissolved (includes Hg)	Field Replicate	Once / Project
Pesticides / Herbicides / TSS	Field Duplicate (split)	Once / Project

Metals

A modified EPA Method 1669 approach has been developed for collection of low-level metals samples. It is critical that any object or substance that contacts the sample is non-metallic and free from any material that may contain metals of concern.

Equipment/Definition:

- Gloves – clean, non-talc polyethylene, latex, vinyl, or PVC
- Storage Bags – clean, zip-type, non-vented, colorless polyethylene
- Cooler – clean, non-metallic, with white interior
- Reagent water – water in which the analytes of interest and potentially interfering substances are not detected at the Method Detection Limit (MDL) of the analytical method used for analysis of samples.

Acid washed, polyethylene 500-ml bottles will be double bagged in ziplock type bags. Sampling personnel are required to wear clean, non-talc gloves at all times when handling sampling equipment and sample containers.

Sample Collection Procedures:

The sampling team should approach the site from down current and downwind to prevent contamination of the sample by particles sloughing off the vehicle or equipment. If it is not possible to approach from downwind, the site should be approached from down current.

Once at the sample site, withdraw the ziplock bag containing the appropriate metals bottle. Unzip the outer bag. Next, a pair of clean gloves is put on and the inside bag containing the sample bottle is then open. After the bottle is removed the inside bag is resealed. Facing upstream, preferably in the portion of the channel with predominant flow, the cap is unscrewed. While holding the cap upside down, the sample bottle is inverted and submerged, allowing the bottle to partially fill with sample. After the cap is screwed back on the bottle shake it several times. Empty the rinsate downstream of the sample site. While avoiding stirring up the sediment, as this can change the test results drastically. After two more rinsings, hold the bottle under water and

allow it to fill with sample. After the bottle has filled, and while the bottle is still inverted so that the mouth of the bottle is underwater, replace the cap of the bottle. This will prevent the sample from coming into contact with the air.

The inside bag is then reopened and the bottle placed back inside. All the ziplock bags are resealed and the package placed inside the cooler.

A new set of gloves must be used for each sample.

Field QC Sampling Procedure for Metals:

Field Blank. To demonstrate that sample contamination has not occurred during field sampling and sample processing one (1) field blank must be generated during each event. Field blanks are “collected” **after** sample collection.

A clean, acid washed, 500 ml polyethylene sample bottle will be filled with reagent water in the laboratory, double bagged, and brought to the field for “collection.” When at the field collection site, and just after sample collection, the field blank container will be removed from the bags as described above. The lid to the field blank will be removed for approximately the same number of seconds that the actual sampling bottle interior was exposed to the ambient air during sampling. The lid will then be replaced and the field blank re-bagged and placed in the cooler with the other samples.

Field Replicate. To assess the precision of the field sampling and analytical processes, at least one (1) field replicate metals sample must be collected at a given site. The field replicate is generated by collecting two samples in rapid succession at the same site.

Field Quality Control Samples

Parameter	Field QC Sample Type	Frequency
Total Metals (includes Hg)	Field Blank	Once / Event
Total Metals (includes Hg)	Field Replicate	Once / Project
Pesticides / Herbicides	Field Blank	Once / Project
Pesticides / Herbicides	Field Duplicate	Once / Project
TSS	Field Duplicate	Once / Project

Sample Identification

Each sample will be identified by a unique laboratory sample number that will be assigned to each sampling location and event. A single sample number will be used for all parameters analyzed from the same sample. Sample numbers will be assigned and sample containers labeled with these sample numbers prior to use in the field. Sample labels will also include information about the sampling location, sampling date, project number, sample matrix, requested analytical parameters and preservative.

KCEL sample identification numbers will be assigned for all samples and will be used as a cross reference for samples going to the Ecology and USGS laboratories. KCEL labels will be provided for Ecology and USGS samples.

Sample Containers

All sample containers for samples to be analyzed at the KCEL will be supplied by the KCEL. These containers will be prewashed and prepared for sampling in accordance with standard operating practice of the KCEL. Sample containers for samples to be analyzed at the USGS Laboratory will be supplied by the USGS. Sample containers for samples analyzed at the Ecology Manchester Laboratory will be obtained from Ecology.

Sample Containers, Preservation and Storage Conditions

Parameter	Matrix	Sampling Container	Container Size	Preservative	Hold Time
USGS-Schedule 2010 pesticides	water	Teflon®	3L	4°C	48 hours extract 14 days analyze
Ecology-Chlorinated organophosphorus & nitrogen containing pesticides	water	Amber glass	1 gallon	4°C	7days extract 40 days analyze
Ecology-Chlorinated Herbicides	water	Amber glass	1 gallon	4°C	7 days extract 40 days analyze
KCEL-Total Metals	water	Polyethylene (acid rinsed)	500ml	HNO ₃ pH < 2 preserved at lab	180 days analyze (28 days Hg)
KCEL-Toxicity	water	glass	3 ea, 2-Liter	4°C	36 hours analyze
Filters	0.7 µ USGS	glass		freeze	
TSS	water	Polyethylene	1 Liter	4° C	7 days analyze

Sample Preservation

Samples will be preserved in accordance with the guidelines and references listed in the above table.

Samples will be preserved as soon as possible after sample collection and always within 24 hours of sampling. After collection, all samples will immediately be placed in an ice-filled, insulated cooler to maintain sample temperature of approximately 4°C until delivery to the laboratory.

Sample Delivery

All samples will be delivered to the various laboratories in sufficient time to allow the laboratories to meet the analytical hold times specified in the table above. Additionally, sample preservation requirements note that samples are to be preserved within 24 hours of sampling.

Samples will be carried by USGS to the National Water Quality laboratory for USGS schedule 2010 analyses, and to Ecology's Manchester Laboratory for chlorinated pesticides, organophosphorus pesticides, chlorinated herbicides, and nitrogen-containing pesticides analyses.

Metals samples must be delivered to the KCEL in sufficient time to allow for sample preservation within 24 hours.

Chain of Custody

The chain-of-custody forms to be used for this project are included as an appendix and attachment to this QA plan. The KCEL chain-of-custody form, or *Laboratory Work Order* form should be initiated in the field as samples are collected and accompany all samples during transport to KCEL (see Appendix). Ecology will provide a chain-of-custody form for samples delivered to their Manchester lab by USGS personnel (see Attachment). USGS will manage Chain-of-Custody for samples delivered to the USGS Laboratory.

The sample release section of the chain-of-custody forms will be completed at the time of sample transfer to the laboratory. Date and time of sample delivery as well as the signature of the individual delivering the samples (Relinquished By) must be filled out at this time. The sample recipient (Received By) completes the chain-of-custody form and provides a copy to the sample deliverer.

At each sampling location, the following information will be recorded on waterproof field notes: date and time of sample collection, sampling personnel, station location information, weather conditions, number and type of samples collected, any unusual ambient conditions, and any deviations from sampling procedures specified in this document. If field measurements are collected or field analyses performed, results are also recorded on the field notes.

5.0 ANALYTICAL PROCEDURES - SUMMARY OF TESTING

A summary of the testing to be conducted for this site is listed below;

Laboratory Analysis Method Summary

Parameter	Matrix	Total Number of Samples***	Method	Laboratory
Organochlorine Pesticides	Water	15	US EPA 8085	Ecology
Chlorophenoxy Herbicides	Water	15	US EPA 8085	Ecology
Organophosphorus Pesticides	Water	15	US EPA 8085	Ecology
Nitrogen Pesticides	Water	15	US EPA 8085	Ecology
Miscellaneous Pesticides	Water*	15	USGS 2010	USGS
Total Metals	Water	18	EPA 200.8	KC Environmental Lab
Dissolved Metals	Water*	18	EPA 200.8	KC Environmental Lab
<i>Ceriodaphnia</i> Chronic Toxicity	Water**	13	EPA 600/4-89/001	KC Environmental Lab
<i>Selenastrum</i> Chronic Toxicity	Water**	13	EPA 600/4-89/001	KC Environmental Lab
<i>Lemna Minor</i>	Water	13		KC Environmental Lab
Total Suspended Solids	Water	13	SM 2540-D	KC Environmental Lab

* filtered

** both filtered and unfiltered

*** Includes QA/QC samples

KCEL Metals Detection Limit Summary

Analyte	Method Detection Limit (µg/L, ppb)
Mercury	0.2
Antimony	0.5
Arsenic	0.5
Beryllium	0.2
Cadmium	0.1
Chromium	0.4
Copper	0.4
Lead	0.2
Nickel	0.3
Selenium	1.5
Silver	0.2
Thallium	0.2
Zinc	0.5
Hardness	0.2 mg CaCO ₃ /L

USGS Schedule 2010 Target Pesticides List for Water Analyses

Analyte	Method Detection Limit (µg/L, ppb)	Analyte	Method Detection Limit (µg/L, ppb)
acetochlor	0.002	malathion	0.005
alachlor	0.002	metolachlor	0.002
atrazine, desethyl-	0.002	metribuzin	0.004
atrazine	0.001	molinate	0.004
azinphos-methyl	0.001	napropamide	0.003
benfluralin	0.002	parathion, ethyl-	0.004
butylate	0.002	parathion, methyl	0.006
carbaryl	0.003	pebulate	0.004
carbofuran	0.003	pendimethalin	0.004
chlorpyrifos	0.004	permethrin, cis	0.005
cyanazine	0.004	phorate	0.002
DCPA (Dacthal)	0.002	pronamide	0.003
4,4' -DDE	0.006	prometon	0.018
diazinon	0.002	propachlor	0.007
dieldrin	0.001	propanil	0.004
2,6-diethylaniline	0.003	propargite	0.013
dusulfoton	0.017	simazine	0.005
EPTC (Eptam)	0.002	thiobencarb	0.002
ethalfluralin	0.004	tebuthiuron	0.010
ethoprop	0.003	terbacil	0.007
fonofos	0.003	terbufos	0.013
alpha-BHC	0.002	triallate	0.001
gamma-BHC (Lindane)	0.004	trifluralin	0.002
linuron	0.002		

WSPMP Target Pesticides List for Water Analyses

Chlorinated Pesticides

Analyte	Quantitation Limit (µg/L, ppb)	Analyte	Quantitation Limit (µg/L, ppb)
4,4'-DDT	0.035	cis-nonachlor	0.035
4,4'-DDE	0.035	trans-nonachlor	0.035
4,4'-DDD	0.035	oxychlordane	0.035
2,4'-DDT	0.035	dicofol (keithane)	0.17
2,4'-DDE	0.035	dieldrin	0.035
2,4'-DDD	0.035	endosulfan I	0.035
DDMU	0.035	endosulfan II	0.035
aldrin	0.035	endosulfan sulfate	0.035
alpha-BHC	0.035	endrin	0.035
beta-BHC	0.035	endrin aldehyde	0.035
delta-BHC	0.035	endrin ketone	0.035
gamma-BHC (Lindane)	0.035	heptachlor	0.035
captan	0.14	heptachlor epoxide	0.035
captafol	0.21	methoxychlor	0.035
cis-chlordane	0.035	mirex	0.035
trans-chlordane	0.035	pentachloroanisole	0.035
alpha-chlordene	0.043	toxaphene	0.85
gamma-chlordene	0.035		

Quantitation limits are approximate and are often different for each sample; these values are representative of a typical sample

WSPMP Target Pesticides List for Water Analyses

Organophosphorus Pesticides

Analyte	Quantitation Limit (µg/L, ppb)	Analyte	Quantitation Limit (µg/L, ppb)
azinphos-ethyl	0.12	fensulfothion	0.075
azinphos-methyl	0.12	fenthion	0.055
carbophenothion	0.80	fonophos	0.045
chlorpyrifos	0.055	imidan	0.080
chlorpyrifos-methyl	0.050	malathion	0.060
coumaphos	0.090	merphos	0.12
DEF	0.11	methamidophos	0.30
demeton-O	0.055	mevinphos	0.075
demeton-S	0.060	paraoxon-methyl	0.15
diazinon	0.060	parathion	0.06
dichlorvos	0.060	parathion-methyl	0.055
dimethoate	0.060	phorate	0.055
dioxathion	0.12	phosphamidan	0.18
disulfoton	0.045	propetamphos	0.15
EPN	0.075	ronnel	0.055
ethion	0.055	sulfotepp	0.045
ethoprop	0.060	suiprofos	0.055
fenamiphos	0.12	temephos	0.70
fenitrothion	0.055	tetrachlorvinphos	0.15

Quantitation limits are approximate and are often different for each sample; these values are representative of a typical sample

WSPMP Target Pesticides List for Water Analyses

Chlorinated Herbicides

Analyte	Quantitation Limit (µg/L, ppb)	Analyte	Quantitation Limit (µg/L, ppb)
2,4-D	0.042	bromoxynil	0.042
2,4-DB	0.050	DCPA (Dacthal)	0.033
2,4,5-T	0.033	dicamba	0.042
2,4,5-TB	0.038	dichlorprop	0.046
2,4,5-TP (Silvex)	0.033	diclofop-methyl	0.063
2,3,4,5 –tetrachlorophenol	0.023	dinoseb	0.063
2,3 ,4,6-tetrachlorophenol	0.023	ioxynil	0.042
2,4,5-trichlorophenol	0.025	MCPA	0.083
2,4,6-trichlorophenol	0.025	MCPP	0.083
3 ,5-dichlorobenzoic acid	0.042	pentachlorophenol	0.021
4-nitrophenol	0.073	picloram	0.042
acifluorfen	0.17	trichlopyr	0.035
bentazon	0.063		

Quantitation limits are approximate and are often different for each sample; these values are representative of a typical sample

WSPMP Target Pesticides List for Water Analyses

Nitrogen-Containing Pesticides

Analyte	Quantitation Limit (µg/L, ppb)	Analyte	Quantitation Limit (µg/L, ppb)
alachlor	0.26	metribuzin	0.071
ametryn	0.071	MGK-264	0.50
atra ton	0.21	molinate	0.14
atrazine	0.071	napropamide	0.21
benefin	0.11	norflurazon	0.14
bromacil	0.28	oxyfluorfen	0.28
butachlor	0.25	pebulate	0.14
butylate	0.14	pendimethalin	0.11
carboxin	0.78	profluralin	0.17
chlorothalonil	0.17	prometon	0.071
chlorpropham	0.28	prometryn	0.071
cyanazine	0.11	pronamide	0.28
cycloate	0.14	propachlor	0.17
diallate	0.27	propazine	0.071
dichlobenil	0.16	simazine	0.072
diphenamid	0.21	tebuthiuron	0.11
diuron	0.48	terbacil	0.21
eptam	0.14	terbutryn	0.071
ethalfluralin	0.11	triadimefon	0.18
fenarimol	0.21	triallate	0.18
hexazinone	0.11	trifluralin	0.11
metalaxyl	0.48	vernolate	0.14
metolachlor	0.28	vernolate	0.14

Quantitation limits are approximate and are often different for each sample; these values are representative of a typical sample

6.0 CHRONIC TOXICITY TESTS

Three chronic toxicity tests, *Ceriodaphnia dubia*, *Selenastrum capricornutum*, and *Lemna minor*, will be performed on all the samples collected at the 3 sites during the 3 sampling events (early and late spring runoff and early fall runoff). The *L. minor* test will be added to assess the toxicity of herbicides that are not toxic to algae. The tests will be initiated within 72 hours of sample collection.

Sample Treatment:

Upon arrival to the laboratory the following water quality parameters will be measured in each 6-L sample from the test and reference sites: temperature, dissolved oxygen, pH, total alkalinity, total hardness and conductivity. Half the volume of each sample will be filtered through a 0.45 μ m Gelman mini capsule filter and the samples will be refrigerated at $4\pm 2^{\circ}\text{C}$ until use. Samples will be mixed before filtering.

Water Flea - *Ceriodaphnia dubia* (7-Day Chronic Toxicity Test)

The *C. dubia* chronic toxicity test will be conducted as outlined in Lewis *et al.* (1994). The undiluted, unfiltered (100%) samples will be tested along with the undiluted, filtered (100%) samples and a 0% filtered and unfiltered sample (Lake Washington water only). Ten replicates containing one organism each will be tested at each treatment. Each test chamber will contain 15 mL of solution in a 30-mL plastic cup. Test organisms will be neonates (< 24h old) taken from an overnight brood board composed of adults isolated from in-house mass cultures. Individual broods will be blocked across treatments with each replicate representing a different brood. One replicate will be assigned per row of the test chamber, and then treatments will be randomized within each row. The test will be incubated for 7 days at $25 \pm 1^{\circ}\text{C}$ on a 16:8 hour light:dark cycle. Solutions will be renewed and animals fed daily. Reproduction, mortality, and water quality measurements will be recorded every 24 hours at the time of solution renewal. Monthly reference toxicant test with cadmium will be used to assess the health of the organisms.

Green Algae - *Selenastrum capricornutum* (96-Hour Chronic Toxicity Test)

The *S. capricornutum* chronic toxicity test will be conducted as outlined in Lewis *et al.* (1994). Briefly, nutrients (including EDTA) equivalent to those in the culture water (algal assay medium, or "AAM") will be added to both the filtered (0.45 μ m) and unfiltered samples in order to ensure that toxicity is not confused with a lack of nutrients. The filtered and unfiltered samples will be tested along with a 0% filtered and unfiltered dilution medium sample (AAM only). Each treatment will be tested with four replicates. Each replicate will consist of 50 mL of solution added to a 125 mL sterile flask covered with an inverted beaker and inoculated with 1 mL at a concentration of 51×10^4 cells/mL, resulting in an initial density of 1.03×10^4 cells/mL. The flasks will be incubated for 96 hours at $25 \pm 1^{\circ}\text{C}$ under constant light (3,780 - 3,880 lux) in a pattern determined by random number assignment. Twice daily the flasks will be mixed and the positions in the incubator rotated. Temperature will be measured daily in the incubator and pH will be measured in each treatment at test initiation and termination. After 96 hours of exposure

the algae growth in each flask is measured by cell counts. Concurrent reference toxicant test with sodium chloride will be used to assess the growth of the algae.

Duckweed - *Lemna minor* (7-Day Chronic Test)

The *Lemna minor* chronic toxicity test will be conducted as outlined in ASTM (1988) with two modifications: the use of a static-renewal procedure and the use of Hoagland's medium at 10% of full strength. The unfiltered (100%) sample will be tested along a unfiltered reference sample (Rock Creek) and a unfiltered medium sample (Hoagland's medium). Each treatment will be tested with four replicates. For each replicate, 50mL of solution will be added to a 70 x 50 mm crystalizing dish and inoculated with 3, 3-frond plants (total of 9 fronds/beaker). The dishes will be positioned randomly and incubated for 7 days at $25 \pm 1^{\circ}\text{C}$ under constant light. Each day the fronds will transferred to fresh solutions and the dishes will be repositioned in the incubator. On day 7, the fronds will be counted and the plants from each replicate will be placed in tared pans and dried at 60°C for dry weight measurement. Concurrent reference toxicant test with sodium chloride will be used to assess the growth of the plant.

Data Analysis

The *C. dubia* survival data from each test site will be compared with the survival data from the reference site based on treatment (100% filtered and 100% unfiltered). In addition, the survival data between the two treatments from each site will be compared. The statistical analysis will be performed using a Chi-square test. The reproduction data from each test site will be compared with the reproduction data from the reference site based on treatment (100% filtered and 100% unfiltered). In addition, the reproduction data between the two treatments from each site will be compared. The statistical analysis will be performed using a t-test or a Wilcoxon rank sum test depending on the normality and homogeneity of the data. The normality and homogeneity of the data will be analyzed using a Shapiro Wilk test and an F-test. Overall test acceptability is based on the survival and reproduction data from the 0% unfiltered Lake Washington sample. The filtered Lake Washington sample will be compared with the unfiltered sample to determine whether filtration had an effect. The statistical analyses will be as listed above. Reference toxicant data will be compared to the control chart and precision table to ensure that the reproduction data (IC25) falls within the control limits (± 2 times standard deviation).

The *S. capricornutum* growth data from each test site will be compared with the growth data from the reference site based on treatment (100% filtered and 100% unfiltered). In addition, the growth data between the two treatments from each site will be compared. The statistical analysis will be performed using a t-test or a Wilcoxon rank sum test depending on the normality and homogeneity of the data. The normality and homogeneity of the data will be analyzed using a Shapiro Wilk test and an F-test. Overall test acceptability is based on the growth data from the 0% unfiltered dilution medium sample (AAM only). The filtered dilution medium sample will be compared with the unfiltered sample to determine if filtration had an effect. The statistical analyses will be as listed above. Reference toxicant data will be compared to the control chart and precision table to ensure that the growth data (EC50) falls within the control limits (± 2 times standard deviation).

The *L. minor* growth data from each test site will be compared with the growth data from the reference site based on treatment (100% filtered and 100% unfiltered). In addition, the growth

data between the two treatments from each site will be compared. The statistical analysis will be performed using a t-test or a Wilcoxon rank sum test depending on the normality and homogeneity of the data. The normality and homogeneity of the data will be analyzed using a Shapiro Wilk test and an F-test. Overall test acceptability is based on the growth data from the unfiltered dilution medium sample (10% Hoagland's medium). The filtered dilution medium sample will be compared with the unfiltered sample to determine if filtration had an effect. The statistical analyses will be as listed above. Reference toxicant data will be compared to the control chart and precision table to ensure that the growth data (EC50) falls within the control limits (± 2 times standard deviation).

7.0 DATA REPORTING

All data are to be reported within 45 days of sample receipt. Data are to be reported to Dean Wilson of King County.

The following information is to be reported for all chemistry data: analyte, CAS number (if applicable), detection limit, result, date prepared, date analyzed, method used, and definition of any qualifiers. Surrogates percent recoveries will be reported for all organic methods.

Data are to be reported in an electronic EXCEL spreadsheet format along with the laboratories standard hard copy report.

Laboratory standard QC are to be reported along with sample data.

Toxicity data are to be reported in standard reporting format, including all water quality values from the studies.

APPENDIX B:
USGS REPORT – PESTICIDES
DETECTED IN URBAN STREAMS IN
KING COUNTY, WASHINGTON, 2000

Pesticides Detected in Urban Streams in King County, Washington, 2000

Lonna M. Frans

Samples for analysis of pesticides and pesticide transformation products were collected at Lyon Creek at Lake Forest Park (USGS site 12127300), Swamp Creek near Bothell, Wash. (USGS site 12127000), Bear Creek at Woodinville, Wash. (USGS site 12125500), and an Irrigation Return draining to the Sammamish River in King County (USGS site 474243122083001). The sites are referred to in this chapter as Lyon Creek, Swamp Creek, Little Bear Creek, and the Irrigation Return, respectively. Samples were collected in 2000 from the streams on May 3, June 27, and October 9, and from the Irrigation Return on September 11.

Sample Collection and Processing for Pesticides

Samples were collected either by an automated sampler (autosampler) or manual sampling. The manual samples were collected using the U.S. DH-81 sampler as described by Edwards and Glysson (1999) and Shelton (1994). The sampler holds a 1-liter or 3-liter Teflon sample bottle, and all parts of the sampler coming into contact with sample water are constructed of Teflon. To collect a sample manually, a transect was established across the width of the creek, and sample water was collected at equally spaced intervals along the transect by dipping the sampler vertically downward from the water surface to the creek bottom. The collected water then was composited in a glass carboy.

Autosamplers were installed in the creeks on two occasions and set to trigger when the level of the creek rose from a rainstorm. When the autosampler was triggered, it pumped water from a single point in the stream through a Teflon tube into a glass carboy (Isco, Inc., 1992).

The composite samples in the glass carboys were split into individual samples for analysis at the U.S. Geological Survey National Water Quality Laboratory (NWQL) in Denver, Colo., and the Washington State Department of Ecology Manchester Environmental Laboratory, in Manchester, Wash., using a Teflon cone splitter (Shelton, 1994). All equipment used to collect and process samples except the autosampler was cleaned with a 0.2-percent nonphosphate detergent, rinsed with deionized water, rinsed with pesticide-grade methanol, air-dried, wrapped in aluminum foil, and stored in a dust-free environment prior to sample collection (Shelton, 1994). All of the autosampler parts that contacted the sample were washed in detergent, soaked in acid for 24 hours, rinsed with deionized water, and stored in plastic bags. The cone splitter and all bottles used to collect stream water were rinsed thoroughly with native water before sample collection and processing.

Samples to be analyzed by the NWQL were filtered through a 0.7-micrometer pore size, baked glass-fiber filter. Known quantities of surrogate compounds were added to the filtrate before it was passed through a solid-phase extraction (SPE) cartridge to extract pesticide compounds. The SPE cartridge was packed with porous silica coated with a carbon-18 organic phase. After extraction, the SPE cartridges were stored in amber pesticide-free vials at less than 4° Celsius and shipped to the NWQL. The equipment required and the procedures used to collect, process,

and extract samples using the SPE method are described in Shelton (1994) and Sandstrom and others (1992).

Samples to be analyzed by the Manchester Environmental Laboratory were collected from the cone splitter in glass bottles, but were not filtered. They were stored on ice during transport to the laboratory.

Laboratory Procedures

The samples were analyzed for a total of 153 pesticides and pesticide transformation products (hereafter referred to as pesticides) by the two laboratories. At the NWQL, pesticides retained on the SPE cartridges were eluted with a hexane-isopropanol mixture and analyzed for 47 pesticides using gas chromatography/mass spectrometry (GC/MS) with selected ion monitoring (Zaugg and others, 1995) (Table B-1). At the Manchester Environmental Laboratory, pesticides present in the whole-water samples were extracted using methylene chloride and analyzed for 142 pesticides (Table B-2) using Draft USEPA Method 8085, which uses capillary column GC analysis with an atomic emission detector (AED) and ion-trap GC/MS confirmation (Huntamer and others, 1992).

Results of Quality-Control Samples

One field blank and one equipment blank were analyzed to assess contamination. Additionally, the laboratories periodically analyze matrix spike samples to measure the recovery of targeted pesticides. In 2000, the NWQL analyzed 441 matrix spike samples, and the Manchester Environmental Laboratory analyzed between 2 and 10 matrix spike samples, depending on the compound. Quality control procedures for the NWQL and Manchester Environmental Laboratory included the use of surrogates, internal standards, and calibration as described by Pritt and Raese (1995) and by Huntamer and others (1992), respectively.

No pesticides were detected in the field or equipment blanks. The percentage of recoveries for the laboratory-matrix spike target compounds typically ranged between 60 and 130 percent, with a few exceptions (Tables B-3, B-4), and were acceptable for data interpretation (Richard Wagner, U.S. Geological Survey, oral commun., 2000). In cases in which a compound had a much lower recovery, such as 4-nitrophenol with a recovery of only 29 percent, the concentration of the compound, if detected in a sample, is likely higher than the reported value because some of the compound was lost during analysis. No modifications were made to the data set based on these results.

There was some overlap of compounds analyzed by the NWQL and Manchester Environmental Laboratory (Table B-5). In cases of overlapping detections, the values reported by the NWQL were used for statistical analysis and interpretation because reporting levels associated with these analyses were usually lower.

Pesticides Detected in Stream Water

A total of 25 different pesticides and pesticide transformation products were detected in water samples (Table B-6). Of the three urban sites, samples from Lyon Creek had the greatest number of pesticides detected. Eighteen pesticides were detected in samples from Lyon Creek, while 15 were detected in samples from Little Bear Creek and 12 were detected in samples from Swamp Creek. Sixteen pesticides were also detected in the Sammamish River Irrigation Return sample.

Of the 25 pesticides detected, 15 were herbicides, 5 were insecticides, 2 were fungicides, and 3 were pesticide transformation products (desethylatrazine is a transformation product of atrazine, 4-nitrophenol is a transformation product of methyl parathion, and 2,6-dichlorobenzamide is a transformation product of diclobenil). The most frequently detected herbicides were prometon and dichlobenil, which were detected in every sample. Diazinon was the most frequently detected insecticide and was also detected in every sample. Six of the detected pesticides (2,6-dichlorobenzamide, carbofuran, diuron, ethofumesate, metalaxyl, and metolachlor) were only found in the Irrigation Return sample.

A major source for the most frequently detected compounds in the urban streams is likely the residential use of pesticides. Homeowners typically use pesticides for lawn and shrub care and for insect control around their property. For example, dichlobenil is a commonly used herbicide for weed control around woody shrubs and trees, and Diazinon, a popular insecticide, is used to control ants, aphids, beetles, and other insects. Of the seven most frequently detected pesticides (2,4-D, Diazinon, dichlobenil, MCPP, pentachlorophenol, prometon, and triclopyr), all but pentachlorophenol are sold for retail use (Voss and Embrey, 2000). Pentachlorophenol, although not available for retail sale, is a popular wood preservative that is used to pressure-treat wood for uses such as utility poles. Several other pesticides that were detected (carbaryl, chlorpyrifos, malathion, MCPA, trifluralin) are also sold in King County home and garden stores and thus are available for residential use (Voss and Embrey, 2000). Dicamba, although it was not listed as being sold in home and garden stores since only the first two active ingredients of a product were recorded, is actually the third active ingredient in several fertilizer-pesticide combination products.

Several of the pesticides that were detected in the Irrigation Return water are likely from agricultural application and others are likely from urban use. The Irrigation Return consists of a small stream that runs out of an urban area and feeds into a ditch that is used by a turf farm for return of irrigation water to the Sammamish River. The turf farm withdraws water from the Sammamish River for irrigation use. Because the Irrigation Return water has both urban and agricultural sources of water, it is difficult to distinguish which pesticides detected in Irrigation Return samples are the result of urban application and which are the result of agricultural application. However, of the six compounds found only in the Irrigation Return sample, five of them (metalaxyl, carbofuran, diuron, ethofumesate, and metolachlor) have no recorded retail sales in King County and are most often associated with agricultural applications (Larson and others, 1997; Hall and Sagan, 1993). The sixth, 2,6-dichlorobenzamide, is a transformation product from the breakdown of dichlobenil, which is sold in retail stores but also used in

agriculture. 2,6-dichlorobenzamide was only analyzed for and detected in the Irrigation Return sample, but it is likely that it would have been detected in the urban stream samples if it had been analyzed for because its parent compound, dichlobenil, was present in all samples.

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Table B-1. Analytes and method detection limits for pesticides analyzed at the U.S. Geological Survey National Water Quality Laboratory

[µg/L, micrograms per liter; H, herbicide; I, insecticide; T, transformation product; --, no trade or common name]

Pesticide target analyte	Trade ¹ or common name(s)	Type of pesti- cide	Chemical Abstracts Service registry number	Method detection limit (µg/L)
2,6-Diethylanaline	--	T	579-66-8	0.003
4,4'-DDE	--	T	72-55-9	0.006
Acetochlor	Acenit, Sacenid	H	34256-82-1	0.002
Alachlor	Lasso	H	15972-60-8	0.002
Atrazine	AAtrex	H	1912-24-9	0.001
Azinphos-methyl ²	Guthion	I	86-50-0	0.001
Benfluralin	Balan, Benefin	H	1861-40-1	0.002
Butylate	Sutan +, Genate Plus	H	2008-41-5	0.002
Carbaryl ²	Sevin, Savit	I	63-25-2	0.003
Carbofuran ²	Furadan	I	1563-66-2	0.003
Chlorpyrifos	Lorsban	I	2921-88-2	0.004
Cyanazine	Bladex	H	21725-46-2	0.004
DCPA	Dacthal	H	1861-32-1	0.002
Desethylatrazine ²	--	T	6190-65-4	0.002
Diazinon	several	I	333-41-5	0.002
Dieldrin	Panoram D-31	I	60-57-1	0.001
Disulfoton	Di-Syston	I	298-04-4	0.017
EPTC	Eptam, Eradicane	H	759-94-4	0.002
Ethalfuralin	Sonalan, Curbit EC	H	55283-68-6	0.004
Ethoprop	Mocap	I	13194-48-4	0.003
Fonofos	Dyfonate	I	944-22-9	0.003
<i>alpha</i> -HCH	--	I	319-84-6	0.002
<i>gamma</i> -HCH	Lindane	I	58-89-9	0.004
Linuron	Lorox, Linex	H	330-55-2	0.002
Malathion	several	I	121-75-5	0.005
Methyl parathion	Penncap-M	I	298-00-0	0.006
Metolachlor	Dual, Pennant	H	51218-45-2	0.002
Metribuzin	Lexone, Sencor	H	21087-64-9	0.004
Molinate	Ordram	H	2212-67-1	0.004
Napropamide	Devrinol	H	15299-99-7	0.003
Parathion	several	I	56-38-2	0.004
Pebulate	Tillam	H	1114-71-2	0.004
Pendimethalin	Prowl, Stomp	H	40487-42-1	0.004
<i>cis</i> -Permethrin	Ambush, Pounce	I	57608-04-5	0.005
Phorate	Thimet, Rampart	I	298-02-2	0.002
Prometon	Pramitol	H	1610-18-0	0.018
Pronamide	Kerb	H	23950-58-5	0.003
Propachlor	Ramrod	H	1918-16-7	0.007
Propanil	Stampede	H	709-98-8	0.004
Propargite	Comite, Omite	I	2312-35-8	0.013

Table B-1. Analytes and method detection limits for pesticides analyzed at the U.S. Geological Survey National Water Quality Laboratory --*Continued*

Pesticide target analyte	Trade ¹ or common name(s)	Type of pesticide	Chemical Abstracts Service registry number	Method detection limit (µg/L)
Simazine	Aquazine, Princep	H	122-34-9	0.005
Tebuthiuron	Spike	H	34014-18-1	0.01
Terbacil ²	Sinbar	H	5902-51-2	0.007
Terbufos	Counter	I	13071-79-9	0.013
Thiobencarb	Bolero	H	28249-77-6	0.002
Triallate	Far-Go	H	2303-17-5	0.001
Trifluralin	Treflan, Trilin	H	1582-09-8	0.002

¹Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government.

²Concentrations for these pesticides are qualitatively identified and reported with an E code (estimated value). E codes are used to signify estimated values for all detections that are below the method detection limit, above the highest calibration standard, or otherwise less reliable than average because of sample-specific or compound-specific considerations. All E-coded data are considered to be reliable detections, but with greater than average uncertainty in quantification.

Table B-2. Analytes and quantitation limits for pesticides analyzed at the Washington State Department of Ecology Manchester Environmental Laboratory

[µg/L, micrograms per liter; H, herbicide; I, insecticide; T, transformation product; F, fungicide; --, no trade or common name]

Pesticide target analyte	Trade ¹ or common name(s)	Type of pesti- cide	Chemical Abstracts Service registry number	Quantitation limit ² (µg/L)
2,3,4,5-Tetrachlorophenol	Dowicide 6	F	4901-51-3	0.023
2,3,4,6-Tetrachlorophenol	Dowicide 6	F	58-90-2	0.023
2,4,5-T	--	H	93-76-5	0.033
2,4,5-TB	--	H	93-80-1	0.038
2,4,5-TP	Silvex	H	93-72-1	0.033
2,4,5-Trichlorophenol	Dowicide 2	F	95-95-4	0.025
2,4,6-Trichlorophenol	Dowicide 2S	F	88-06-2	0.025
2,4-D	Weed-B-Gon, Weedone	H	94-75-7	0.042
2,4-DB	Venceweed, Butoxone	H	94-82-6	0.050
2,4'-DDD	TDE	I	53-19-0	0.035
2,4'-DDE	--	T	3424-82-6	0.035
2,4'-DDT	DDT	I	789-02-6	0.035
2,6-Dichlorobenzamide	--	T	2008-58-4	0.081
3,5-Dichlorobenzoic Acid	--	H	51-36-5	0.042
4,4'-DDD	TDE	I	72-54-8	0.035
4,4'-DDE	--	T	72-55-9	0.035
4,4'-DDT	DDT	I	50-29-3	0.035
4-Nitrophenol	--	T	100-02-7	0.073
Acifluorfen	Blazer	H	62476-59-9	0.17
Alachlor	Lasso	H	15972-60-8	0.26
Aldrin	Aldrex	I	309-00-2	0.035
Ametryn	Evik, Gesapax	H	834-12-8	0.071
Atraton	Gesatamin	H	1610-17-9	0.21
Atrazine	AAtrex	H	1912-24-9	0.071
Azinphos-methyl	Guthion	I	86-50-0	0.12
Azinphos ethyl	Azinos, Gusathion A	I	2652-71-9	0.12
Benfluralin	Benefin, Balan	H	1861-40-1	0.11
Bentazon	Basagran	H	25057-89-0	0.063
Bromacil	Hyvar, Urox B	H	314-40-9	0.28
Bromoxynil	Buctril, Brominal	H	1689-84-5	0.042
Butachlor	Lambast, Butanox	H	23184-66-9	0.25
Butylate	Sutan +, Genate Plus	H	2008-41-5	0.14
Captafol	Difolatan, Haipen	F	2425-06-1	0.21
Captan	Orthocide	F	133-06-2	0.14
Carbophenothion	Trithion	I	786-19-6	0.80
Carboxin	Oxatin, Viatavax	F	5234-68-4	0.78
cis-Chlordane	Belt	I	5103-71-9	0.035
trans-Chlordane	Belt	I	5103-74-2	0.035
alpha-Chlordene	--	I	56534-02-2	0.043
gamma-Chlordene	--	I	56534-04-G	0.035
Chlorothalonil	Daconil, Bravo	F	1897-45-6	0.17

Table B-2. Analytes and quantitation limits for pesticides analyzed at the Washington State Department of Ecology Manchester Environmental Laboratory --**Continued**

Pesticide target analyte	Trade or common name(s)	Type of pesti- cide	Chemical Abstracts Service registry number	Quantitation limit ¹ (µg/L)
Chlorpropham	Taterpex, Sprout Nip	H	101-21-3	0.28
Chlorpyrifos	Lorsban	I	2921-88-2	0.055
Coumaphos	Agridip	I	56-72-4	0.090
Cyanazine	Bladex	H	21725-46-2	0.11
Cycloate	Sabet	H	1134-23-2	0.14
DCPA	Dacthal	H	1861-32-1	0.033
DDMU	--	T	1022-22-6	0.035
Demeton-O	Systox	I	298-03-3	0.055
Demeton-S	Systox	I	126-75-0	0.060
Di-allate	Avadex	H	2303-16-4	0.27
Diazinon	several	I	333-41-5	0.06
Dicamba	Banvel	H	1918-00-9	0.042
Dichlobenil	Barrier, Casoron	H	1194-65-6	0.16
Dichlorprop	2,4-DP, Seritox 50	H	120-36-5	0.046
Dichlorvos	DDVP	I	62-73-7	0.060
Dicofol	Kelthane	I	115-32-2	0.17
Diclofop-Methyl	Hoelon	H	51338-27-3	0.063
Dieldrin	Panoram D-31	I	60-57-1	0.035
Dimethoate	Cygon 400, Trounce	I	60-51-5	0.060
Dinoseb	DNBP, Dinitro	H	88-85-7	0.063
Dioxathion	--	I	78-34-2	0.12
Diphenamid	Dymid	H	957-51-7	0.21
Disulfoton	Di-Syston	I	298-04-4	0.045
Diuron	Karmex, Direx	H	330-54-1	0.48
Endosulfan I	several	I	959-98-8	0.035
Endosulfan II	several	I	33213-65-9	0.035
Endosulfan Sulfate	--	T	1031-07-8	0.035
Endrin	Hexadrin	I	72-20-8	0.035
Endrin Aldehyde	--	T	7421-93-4	0.035
Endrin Ketone	--	T	53494-70-5	0.035
EPN	--	I	2104-64-5	0.075
EPTC	Eptam, Eradicane	H	759-94-4	0.14
Ethalfuralin	Sonalan, Curbit EC	H	55283-68-6	0.11
Ethion	Ethiosul	I	563-12-2	0.055
Ethofumesate ³	Nortron, Tramet	H	26225-79-6	--
Ethoprop	Mocap	I	13194-48-4	0.060
Fenamiphos	Nemacur	I	22224-92-6	0.12
Fenarimol	Rubigan	F	60168-88-9	0.21
Fenitrothion	Fenitox, Rothion	I	122-14-5	0.055
Fensulfothion	Dasanit	I	115-90-2	0.075
Fenthion	Baytex	I	55-38-9	0.055
Fonofos	Dyfonate	I	944-22-9	0.045
<i>alpha</i> -HCH	--	T	319-84-6	0.035
<i>beta</i> -HCH	--	I	319-85-7	0.035

Table B-2. Analytes and quantitation limits for pesticides analyzed at the Washington State Department of Ecology Manchester Environmental Laboratory --*Continued*

Pesticide target analyte	Trade or common name(s)	Type of pesti- cide	Chemical Abstracts Service registry number	Quantitation limit ¹ (µg/L)
<i>delta</i> -HCH	--	I	319-86-8	0.035
<i>gamma</i> -HCH	Lindane	I	58-89-9	0.035
Heptachlor	Fennotox	I	76-44-8	0.035
Heptachlor Epoxide	--	T	1024-57-3	0.035
Hexazinone	Velpar	H	51235-04-2	0.11
Ioxynil	Certrol H	H	1689-83-4	0.042
Malathion	several	I	121-75-5	0.060
MCPA	Metaxon, Kilsem	H	94-74-6	0.083
MCPP	Mecoprop	H	93-65-2	0.083
Merphos (1 & 2)	Folex	H	150-50-5	0.12
Metalaxyl	Apron	F	57837-19-1	0.48
Methoxychlor	Marlate	I	72-43-5	0.035
Methyl Chlorpyrifos	Reldan	I	5598-13-0	0.050
Methyl Paraoxon	--	T	950-35-6	0.15
Methyl Parathion	Pennacp-M	I	298-00-0	0.055
Metolachlor	Dual, Pennant	H	51218-45-2	0.28
Metribuzin	Lexone, Sencor	H	21087-64-9	0.071
Mevinphos	Phosdrin	I	7786-34-7	0.075
MGK264	--	I	113-48-4	0.50
Mirex	--	I	2385-85-5	0.035
Molinate	Ordram	H	2212-67-1	0.14
Napropamide	Devrinol	H	15299-99-7	0.21
<i>cis</i> -Nonachlor	--	I	5103-73-1	0.035
<i>trans</i> -Nonachlor	--	I	39765-80-5	0.035
Norflurazon	Evital, Solicam	H	27314-13-2	0.14
Oxychlorfene	--	T	27304-13-8	0.035
Oxyfluorfen	Goal	H	42874-03-3	0.28
Parathion	several	I	56-38-2	0.06
Pebulate	Tillam	H	1114-71-2	0.14
Pendimethalin	Prowl, Stomp	H	40487-42-1	0.11
Pentachlorophenol	PCP, Penta	F	87-86-5	0.021
Phorate	Thimet, Rampart	I	298-02-2	0.055
Phosmet	Imidan	I	732-11-6	0.080
Phosphamidan	--	I	297-99-4	0.18
Picloram	Tordon	H	1918-02-1	0.042
Profluralin	Tolban	H	26399-36-0	0.17
Prometon	Pramitol	H	1610-18-0	0.071
Prometryn	Caparol, Gesagard	H	7287-19-6	0.071
Pronamide	Kerb	H	23950-58-5	0.28
Propachlor	Ramrod	H	1918-16-7	0.17
Propazine	Prozinex	H	139-40-2	0.071
Propetamphos	Safrotrin	I	31218-83-4	0.15
Ronnel	Fenclophos	I	299-84-3	0.055

Table B-2. Analytes and quantitation limits for pesticides analyzed at the Washington State Department of Ecology Manchester Environmental Laboratory --*Continued*

Pesticide target analyte	Trade or common name(s)	Type of pesti- cide	Chemical Abstracts Service registry number	Quantitation limit ¹ (µg/L)
Simazine	Aquazine, Princep	H	122-34-9	0.072
Sulfotep	Bladafum	I	3689-24-5	0.045
Sulprofos	Bolstar	I	35400-43-2	0.055
Tebuthiuron	Spike	H	34014-18-1	0.11
Temephos	Abate	I	3383-96-8	0.70
Terbacil	Sinbar	H	5902-51-2	0.21
Terbutryn	Igran	H	886-50-0	0.071
Tetrachlorvinphos	Gardona	I	961-11-5	0.15
Toxaphene	Camphechlor	I	8001-35-2	0.85
Triadimefon	Bayleton	F	43121-43-3	0.18
Triallate	Far-Go	H	2303-17-5	0.18
Tribufos	DEF	H	78-48-8	0.11
Trichlopyr	Garlon, Grazon	H	55335-06-3	0.035
Trifluralin	Treflan, Trilin	H	1582-09-8	0.11
Vernolate	Vernam, Surpass	H	1929-77-7	0.14

¹Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government.

²Quantitation limits are approximate and are often different for each sample; these values are representative of a typical sample

³Non-target analyte

Table B-3. Summary of percentage of mean recoveries from laboratory-reagent-spike pesticide analyses for 2000 for the U.S. Geological Survey National Water Quality Laboratory

Pesticide target analyte	Mean recovery (percent)	Standard deviation (percent)
2,6-Diethylaniline	86	18.3
4,4-DDE	59	11.1
Acetochlor	103	18.6
Alachlor	102	19.0
Atrazine	99	18.4
Azinphos-methyl	83	40.0
Benfluralin	69	18.2
Butylate	89	12.9
Carbaryl	151	107.0
Carbofuran	139	70.8
Chlorpyrifos	90	17.5
Cyanazine	109	27.7
DCPA	100	17.3
Desethylatrazine	67	15.1
Diazinon	95	14.9
Dieldrin	92	17.5
Disulfoton	43	27.3
EPTC	92	12.4
Ethalfuralin	80	19.2
Ethoprop	89	19.7
Fonofos	92	16.2
<i>alpha</i> -HCH	92	14.1
<i>gamma</i> -HCH	95	16.1
Linuron	98	42.1
Malathion	100	25.3
Metolachlor	102	21.7
Metribuzin	97	18.5
Molinate	93	12.6
Napropamide	98	21.6
Parathion	95	27.6
Parathion-methyl	91	25.3
Pebulate	92	12.2
Pendimethalin	80	20.9

Pesticide target analyte	Mean recovery (percent)	Standard deviation (percent)
<i>cis</i> -Permethrin ¹	43	12.5
Phorate	67	21.3
Prometon	99	20.6
Pronamide	96	17.9
Propachlor	103	18.3
Propanil	108	23.2
Propargite	78	24.0
Simazine	102	22.7
Tebuthiuron	123	26.8
Terbacil	110	39.9
Terbufos	73	21.1
Thiobencarb	99	16.3
Triallate	92	14.8
Trifluralin	74	19.3

¹Spike solution contains both *cis*- and *trans*- permethrin, but only the *cis* isomer is reported. *Cis*-permethrin is commonly recovered at about 40 percent in laboratory spike samples.

Table B-4. Summary of percentage of mean recoveries from laboratory-reagent-spike pesticide analyses for 2000 for the Washington State Department of Ecology Manchester Environmental Laboratory

[--, standard deviation not computed for analytes with only two spike analyses]

Pesticide target analyte	Mean recovery (percent)	Standard deviation (percent)
2,3,4,5-Tetrachlorophenol	101	11.9
2,3,4,6-Tetrachlorophenol	97	10.9
2,4,5-T	74	18.5
2,4,5-TB	92	10.8
2,4,5-TP (Silvex)	90	15.0
2,4,5-Trichlorophenol	133	25.7
2,4,6-Trichlorophenol	97	8.3
2,4-D	66	15.0
2,4-DB	94	15.1
2,4'-DDD	100	5.4
2,4'-DDE	90	10.0
2,4'-DDT	89	9.1
3,5-Dichlorobenzoic Acid	77	11.8
4,4'-DDD	111	31.9
4,4'-DDE	109	30.1
4,4'-DDT	106	20.5
4-Nitrophenol	29	4.2
Acifluorfen	67	14.0
Alachlor	98	16.8
Aldrin	74	27.4
Ametryn	64	17.3
Atrazine	94	12.8
Azinphos-methyl	119	15.1
Azinphos ethyl	82	3.4
Benfluralin	72	5.4
Bentazon	95	7.5
Bromacil	105	25.8
Bromoxynil	90	16.8
Butachlor	90	--
Butylate	68	2.6
Captafol	82	30.6
Captan	91	13.2
Carbophenothion	92	5.8

Pesticide target analyte	Mean recovery (percent)	Standard deviation (percent)
Carboxin	51	--
cis-Chlordane	157	--
trans-Chlordane	109	30.7
Chlorothalonil	79	16.2
Chlorpropham	90	7.8
Chlorpyrifos	107	8.4
Coumaphos	118	23.5
Cyanazine	80	6.1
Cycloate	81	8.7
DCPA	93	7.4
DDMU	102	
Demeton-O	39	2.5
Demeton-S	101	6.5
Di-allate	98	--
Diazinon	108	13.1
Dicamba	53	11.2
Dichlobenil	81	15.5
Dichlorprop	83	14.1
Dichlorvos	82	--
Dicofol	66	4.9
Diclofop-methyl	85	15.8
Dieldrin	109	30.1
Dimethoate	105	--
Dinoseb	70	30.2
Dioxathion	29	--
Diphenamid	95	13.3
Disulfoton	83	3.6
Diuron	50	--
Endosulfan I	112	34.3
Endosulfan II	110	30.2
Endosulfan Sulfate	109	32.9
Endrin	110	28.4
Endrin Aldehyde	96	19.4
Endrin Ketone	109	28.6
EPN	83	10.1
EPTC	82	2.4
Ethalfuralin	90	11.1
Ethion	100	8.8
Ethoprop	101	10.0
Fenamiphos	75	--

Pesticide target analyte	Mean recovery (percent)	Standard deviation (percent)
Fenarimol	89	--
Fenitrothion	80	8.0
Fensulfothion	126	--
Fenthion	117	10.7
Fluridone	107	25.6
Fonofos	94	3.2
alpha-HCH	109	32.9
beta-HCH	113	31.7
delta-HCH	111	29.3
gamma-HCH	134	43.4
Heptachlor	77	26.9
Heptachlor Epoxide	109	31.4
Hexazinone	51	15.4
Ioxynil	91	19.5
Malathion	91	5.9
MCPA	74	14.5
MCPP	85	14.4
Merphos (1 & 2)	81	3.4
Metalaxyl	89	--
Methoxychlor	100	21.9
Methyl Chlorpyrifos	93	7.7
Methyl Paraoxon	89	--
Methyl Parathion	105	8.0
Metolachlor	98	12.1
Metribuzin	95	18.0
Mevinphos	84	
MGK264	94	
Mirex	92	2.5
Molinate	82	5.4
Napropamide	97	18.1
cis-Nonachlor	107	--
trans-Nonachlor	96	8.8
Norflurazon	108	18.1
Oxychlorane	101	
Oxyfluorfen	95	15.4
Parathion	107	10.0
Pebulate	91	13.9
Pendimethalin	94	6.0
Pentachlorophenol	102	13.6
Phorate	96	16.9

Pesticide target analyte	Mean recovery (percent)	Standard deviation (percent)
Phosmet	120	5.7
Phosphamidan	56	--
Picloram	16	5.4
Profluralin	79	3.4
Prometon	59	21.4
Prometryn	103	18.8
Pronamide	100	16.8
Propachlor	95	13.2
Propazine	83	6.0
Propetamphos	56	--
Ronnel	102	15.5
Simazine	103	21.1
Sulfotep	104	3.0
Sulprofos	105	13.3
Tebuthiuron	104	18.8
Temephos	49	--
Terbacil	109	23.7
Terbutryn	80	14.9
Tetrachlorvinphos	85	--
Triadimefon	98	--
Tribufos	99	--
Trichlopyr	84	15.2
Trifluralin	95	9.3
Vernolate	76	2.2

Table B-5. Concentrations of all overlapping pesticides and pesticide transformation products detected in 2000 by either the U.S. Geological Survey National Water Quality Laboratory or the Washington State Department of Ecology Manchester Environmental Laboratory

[NWQL, U.S. Geological Survey National Water Quality Laboratory values; WDOE, Washington State Department of Ecology Manchester Environmental Laboratory values; J, Estimated value; N, there is evidence that the analyte is present; <, less than. All values are in micrograms per liter]

Site name	Date	Time	Atrazine		Chlorpyrifos		Diazinon		Malathion		Metolachlor	
			NWQL	WDOE	NWQL	WDOE	NWQL	WDOE	NWQL	WDOE	NWQL	WDOE
Lyon Creek	5/3/00	0930	0.017	0.0099	<0.004	0.003	0.059	0.054	<0.005	<0.016	<0.002	<0.081
	5/3/00	1345	0.008	0.014	<0.004	0.003	0.099	0.13	<0.005	<0.018	<0.002	<0.089
	6/27/00	1115	<0.001	0.004	<0.004	<0.018	0.005	0.0072	<0.005	<0.018	<0.002	<0.089
	10/9/00	1230	<0.007	<0.071	<0.005	<0.022	0.044	0.031	<0.027	<0.022	<0.013	<0.11
Swamp Creek	5/3/00	1200	<0.001	<0.02	<0.004	<0.016	0.025	0.019	0.032	0.013	<0.002	<0.081
	5/3/00	1500	<0.001	<0.02	<0.004	<0.016	0.030	0.021	0.021	0.0069	<0.002	<0.078
	6/27/00	1310	<0.001	0.007	<0.004	<0.019	0.004	0.0044	<0.005	<0.019	<0.002	<0.093
	10/9/00	1340	<0.007	<0.023	<0.005	<0.018	0.029	0.017	<0.027	<0.018	<0.013	<0.092
Little Bear Creek	5/3/00	1100	0.005	<0.02	<0.004	<0.016	0.008	0.01	<0.005	<0.016	<0.002	<0.081
	5/3/00	1340	<0.005	<0.021	<0.004	<0.017	0.007	0.0066	<0.005	<0.017	<0.002	<0.083
	6/27/00	1130	<0.001	<0.022	<0.004	<0.018	<0.002	0.0057	<0.005	<0.018	<0.002	<0.089
	10/9/00	1315	<0.007	<0.024	<0.005	<0.019	<0.005	0.0098	<0.027	<0.019	<0.013	<0.095
Irrigation return	9/11/00	1230	<0.006	<0.023	0.005	<0.019	0.586	0.47	<0.005	<0.019	0.007	<0.093

Site name	Date	Time	Prometon		Simazine		Tebuthiuron		Trifluralin	
			NWQL	WDOE	NWQL	WDOE	NWQL	WDOE	NWQL	WDOE
Lyon Creek	5/3/00	0930	0.032	<0.041	0.033	0.015	<0.010	<0.061	<0.002	<0.03
	5/3/00	1345	0.045	<0.045	0.045	0.046	<0.010	<0.067	<0.002	<0.033
	6/27/00	1115	0.009	<0.022	0.008	<0.022	0.009	<0.033	0.003	<0.033
	10/9/00	1230	0.021	<0.028	0.10	<0.028	<0.016	<0.042	<0.009	<0.042
Swamp Creek	5/3/00	1200	0.020	<0.040	<0.01	<0.020	<0.010	<0.061	<0.002	<0.03
	5/3/00	1500	0.021	<0.039	<0.01	<0.020	<0.010	<0.059	<0.002	<0.029
	6/27/00	1310	0.011	<0.023	0.007	<0.023	<0.010	<0.035	<0.002	<0.035
	10/9/00	1340	0.008	<0.023	<0.011	<0.023	<0.016	<0.035	<0.009	<0.035
Little Bear Creek	5/3/00	1100	0.007	<0.041	<0.01	<0.020	0.015	<0.061	<0.002	<0.03
	5/3/00	1340	0.012	<0.042	<0.005	<0.021	0.022	<0.063	<0.002	<0.031
	6/27/00	1130	0.003	<0.022	0.005	<0.022	0.009	<0.033	<0.002	<0.033
	10/9/00	1315	0.016	<0.024	<0.011	<0.024	<0.016	<0.036	<0.009	<0.036
Irrigation return	9/11/00	1230	0.007	<0.023	<0.005	<0.023	0.076	<0.037	0.003	<0.033

Table B-6. Concentrations of pesticides and pesticide transformation products detected in stream-water samples, King County, Washington, 2000

[J, estimated value; N, there is evidence that the analyte is present; *, pesticide transformation product; <, less than; NA, not analyzed; All pesticide concentrations are in micrograms per liter]

2,6-Dichloro-benzamide*																
Site name	Date	Time	Collection method	2,4-D	4-Nitro-phenol*	Atrazine	Bromacil	Carbaryl	Carbo-furan	Chlor-pyrifos	Desethyl-atrazine*	Diaz-inon	Dicamba	Dichlobenil		
Lyon Creek	5/3/00	0930	Autosampler	0.200	NA	<0.15	0.017	<0.081	^J 0.207	<0.003	^{NJ} 0.003	<0.002	0.059	<0.083	0.110	
	5/3/00	1345	Manual	0.290	NA	<0.16	0.008	^{NJ} 0.013	^J 0.164	<0.003	^{NJ} 0.003	<0.002	0.099	<0.089	0.100	
	6/27/00	1115	Manual	<0.110	NA	<0.19	^{NJ} 0.004	^J 0.050	<0.003	<0.003	<0.004	^J 0.003	0.005	<0.110	^J 0.013	
	10/9/00	1230	Autosampler	0.200	NA	0.29	<0.007	<0.110	<0.060	<0.020	<0.004	<0.006	0.044	^J 0.026	0.071	
Swamp Creek	5/3/00	1200	Autosampler	^J 0.058	NA	<0.14	<0.001	<0.081	<0.015	<0.003	<0.004	<0.002	0.025	<0.082	^J 0.025	
	5/3/00	1500	Manual	^J 0.055	NA	<0.15	<0.001	<0.078	<0.015	<0.003	<0.004	<0.002	0.030	<0.083	^J 0.018	
	6/27/00	1310	Manual	<0.110	NA	<0.19	^{NJ} 0.007	<0.093	<0.003	<0.003	<0.004	<0.002	^J 0.004	<0.110	^J 0.021	
	10/9/00	1340	Autosampler	0.120	NA	^J 0.17	<0.007	<0.092	<0.041	<0.020	<0.005	<0.006	0.029	<0.110	^J 0.023	
Little Bear Creek	5/3/00	1100	Autosampler	0.230	NA	<0.14	0.005	<0.081	^J 0.018	<0.003	<0.004	<0.002	0.008	<0.078	^J 0.029	
	5/3/00	1340	Manual	0.180	NA	<0.15	<0.005	<0.083	<0.020	<0.003	<0.004	<0.002	0.007	<0.083	^J 0.011	
	6/27/00	1130	Manual	<0.100	NA	<0.18	<0.001	<0.089	<0.003	<0.003	<0.004	^J 0.003	^J 0.0057	<0.10	0.060	
	10/9/00	1315	Autosampler	0.520	NA	0.25	<0.007	<0.095	<0.041	<0.400	<0.005	<0.006	^J 0.0098	^J 0.012	^J 0.034	
Irrigation return	9/11/00	1230	Manual	0.280	^J 0.21	<0.19	<0.006	<0.093	<0.003	^J 0.229	0.005	<0.002	0.586	0.380	^J 0.041	
Etho-fume-sate																
Site name	Date	Time	Collection Method	Diuron	Mala-thion	MCPA	MCP	Metal-axyl	Metol-achlor	Penta-chloro-phenol	Prometon	Simazine	Tebuth-iuron	Tri-clopyr	Tri-fluralin	
Lyon Creek	5/3/00	0930	Autosampler	<0.240	NA	<0.005	^J 0.056	^J 0.084	<0.24	<0.002	^J 0.026	0.032	0.033	<0.010	0.100	<0.002
	5/3/00	1345	Manual	<0.270	NA	<0.005	^{NJ} 0.036	0.180	<0.27	<0.002	^J 0.034	0.045	0.045	<0.010	0.061	<0.002
	6/27/00	1115	Manual	<0.130	NA	<0.005	<0.210	<0.210	<0.13	<0.002	<0.054	^J 0.009	0.008	^J 0.00	<0.090	^J 0.003
	10/9/00	1230	Autosampler	<0.170	NA	<0.022	<0.220	0.390	<0.17	<0.013	0.120	0.021	0.100	<0.016	0.100	<0.009
Swamp Creek	5/3/00	1200	Autosampler	<0.240	NA	0.032	^J 0.026	^J 0.068	<0.24	<0.002	^J 0.020	0.020	<0.010	<0.010	0.120	<0.002
	5/3/00	1500	Manual	<0.230	NA	0.021	^J 0.031	^J 0.066	<0.23	<0.002	^J 0.014	0.021	<0.010	<0.010	0.130	<0.002
	6/27/00	1310	Manual	<0.140	NA	<0.005	<0.210	<0.210	<0.14	<0.002	<0.054	^J 0.011	0.007	<0.010	<0.090	<0.002
	10/9/00	1340	Autosampler	<0.140	NA	<0.018	<0.220	^J 0.140	<0.14	<0.013	0.079	^J 0.008	<0.011	<0.016	0.110	<0.009
Little Bear Creek	5/3/00	1100	Autosampler	<0.240	NA	<0.005	^{NJ} 0.020	0.170	<0.24	<0.002	0.092	^J 0.007	<0.010	0.01	0.180	<0.002
	5/3/00	1340	Manual	<0.250	NA	<0.005	<0.170	^J 0.057	<0.25	<0.002	^J 0.027	^J 0.012	<0.005	0.02	0.150	<0.002
	6/27/00	1130	Manual	<0.130	NA	<0.005	<0.200	<0.200	<0.13	<0.002	<0.050	^J 0.003	0.005	^J 0.00	<0.084	<0.002
	10/9/00	1315	Autosampler	<0.210	NA	<0.019	<0.230	^J 0.200	<0.14	<0.013	^J 0.052	0.016	<0.011	<0.016	0.740	<0.009
Irrigation return	9/11/00	1230	Manual	^{NJ} 0.052	^{NJ} 2.4	<0.005	<0.220	<0.220	0.15	0.007	^{NJ} 0.029	^J 0.007	<0.005	^J 0.07	0.280	^J 0.003

**APPENDIX C:
RESULTS OF METAL ANALYSIS
CONDUCTED AT KING COUNTY
ENVIRONMENTAL LAB**

Table C-1. Analytes and Quantitation Limits for Metals and Parameters Analyzed at the King County Environmental Laboratory

Metal or Parameter Measured Chemical	MDL	RDL	Units
M=CV SM2540-D (03-01-009-001)			
Total Suspended Solids	0.5	1	mg/L
Total Suspended Solids, 0.45	1	2	mg/L
M=CV SM5310-B (03-04-001-000)			
Dissolved Organic Carbon	0.5	1	mg/L
M=CV SM5310-B (03-04-001-001)			
Total Organic Carbon	0.5	1	mg/L
M=MT EPA 200.8 (06-03-004&004A-001)			
Antimony, Dissolved, ICP-MS			
Antimony, Total, ICP-MS	0.0005	0.0025	mg/L
Arsenic, Dissolved, ICP-MS			
Arsenic, Total, ICP-MS	0.0005	0.0025	mg/L
Barium, Dissolved, ICP-MS			
Barium, Total, ICP-MS	0.0002	0.001	mg/L
Beryllium, Dissolved, ICP-MS			
Beryllium, Total, ICP-MS	0.0002	0.001	mg/L
Cadmium, Dissolved, ICP-MS			
Cadmium, Total, ICP-MS	0.0001	0.0005	mg/L
Chromium, Dissolved, ICP-MS			
Chromium, Total, ICP-MS	0.0004	0.002	mg/L
Cobalt, Dissolved, ICP-MS			
Copper, Dissolved, ICP-MS			
Copper, Total, ICP-MS	0.0004	0.002	mg/L
Lead, Dissolved, ICP-MS			
Lead, Total, ICP-MS	0.0002	0.001	mg/L
Molybdenum, Dissolved, ICP-MS			
Molybdenum, Total, ICP-MS	0.0005	0.0025	mg/L
Nickel, Dissolved, ICP-MS			
Nickel, Total, ICP-MS	0.0003	0.0015	mg/L
Selenium, Dissolved, ICP-MS			
Selenium, Total, ICP-MS	0.0015	0.0075	mg/L
Silver, Dissolved, ICP-MS			
Silver, Total, ICP-MS	0.0002	0.001	mg/L
Thallium, Dissolved, ICP-MS			
Thallium, Total, ICP-MS	0.0002	0.001	mg/L
Vanadium, Dissolved, ICP-MS			
Vanadium, Total, ICP-MS	0.0003	0.0015	mg/L
Zinc, Dissolved, ICP-MS			
Zinc, Total, ICP-MS	0.0005	0.0025	mg/L
M=MT EPA 245.2 (06-01-004-001)			
Mercury, Dissolved, CVAA			
Mercury, Total, CVAA	0.0002	0.0006	mg/L
M=MT SM2340B.ED19 (06-02-004-002)			
Hardness, Calc	0.2	1.25	mg CaCO3/L

MDL = Minimum detection limit

RDL = Reliability detection limit

Table C-2. Summary of results of blank analysis for the King County Environmental Laboratory

Metal or Parameter Measured	Value	MDL	RDL	Units
Arsenic, Dissolved, ICP-MS		0.0005	0.0025	mg/L
Barium, Dissolved, ICP-MS		0.0005	0.0025	mg/L
Beryllium, Dissolved, ICP-MS		0.0002	0.001	mg/L
Cadmium, Dissolved, ICP-MS		0.0002	0.001	mg/L
Chromium, Dissolved, ICP-MS		0.0001	0.0005	mg/L
Cobalt, Dissolved, ICP-MS		0.0004	0.002	mg/L
Lead, Dissolved, ICP-MS		0.0004	0.002	mg/L
Molybdenum, Dissolved, ICP-MS		0.0002	0.001	mg/L
Nickel, Dissolved, ICP-MS		0.0005	0.0025	mg/L
Selenium, Dissolved, ICP-MS		0.0003	0.0015	mg/L
Silver, Dissolved, ICP-MS		0.0015	0.0075	mg/L
Thallium, Dissolved, ICP-MS		0.0002	0.001	mg/L
Vanadium, Dissolved, ICP-MS		0.0002	0.001	mg/L
Zinc, Dissolved, ICP-MS		0.0003	0.0015	mg/L
M=MT EPA 245.2 (06-01-004-001)		0.0005	0.0025	mg/L
M=MT SM2340B.ED19 (06-02-004-002)		0.0002	0.0006	mg/L

Table C-3. Concentrations of metals detected in stream-water samples, King County, Washington, 2000 [All metals were analyzed using ICP-MS and all concentrations are in milligrams per liter]

Date	03-May-00			03-May-00			27-Jun-00			08-Oct-00			11-Sep-00
Site	Lyon Creek	Little Bear Creek	Swamp Creek	Lyon Creek	Little Bear Creek	Swamp Creek	Lyon Creek	Little Bear Creek	Swamp Creek	Lyon Creek	Little Bear Creek	Swamp Creek	Sammamish Irrigation Return
Time	13:45	13:40	15:00	9:30	11:00	12:00	1040	1130	1310	1230	1315	1340	NR
Sample Method	Manual	Manual	Manual	Autosampler	Autosampler	Autosampler	Manual	Manual	Manual	Manual	Manual	Manual	Manual
TSS	28.1	29.7	31.9	78.8	28.8	21.3	35.6	6.4	3.1	171	37.2	20.3	32
TSS, 0.45	30	31.6	32.9	82	30	21.8	31.3	11.5	4.9	172	38	21.3	152
DOC	4.86	5.24	5.46	5.71	5.37	5.03	3.96	3.82	4.39	9.11	6.17	5.85	8.95
TOC	5.96	6.54	5.97	7.61	6.54	5.24	5.29	4.5	4.28	20.6	9.64	7.67	14.3
Aluminum, Total,							0.165						3.32
Antimony, Total,				0.00054						0.00076	0.00081		
Arsenic (dis)	0.00068	0.0014	0.0012	0.0009	0.0013	0.0013	0.0012	0.0018	0.0016	0.0014	0.0013	0.0016	0.0017
Arsenic Total	0.0016	0.0023	0.0021	0.00269	0.0025	0.0017	0.0023	0.0024	0.0018	0.00675	0.00258	0.0023	0.00316
Barium (dis)	0.00762	0.0104	0.0102	0.00959	0.00954	0.0102	0.0104	0.0092	0.0101	0.00846	0.00866	0.00848	0.0149
Barium Total	0.0142	0.0205	0.0186	0.0276	0.018	0.0153	0.021	0.012	0.012	0.0572	0.0193	0.0154	0.0425
Cadmium Total		0.00023		0.00014	0.0002					0.00032	0.0002		0.00011
Chromium (dis)	0.00046	0.00048		0.00094	0.00051	0.00058	0.00046	0.00054	0.00047				0.00047
Chromium Total	0.00211	0.00262	0.0016	0.00539	0.00222	0.0014	0.00316	0.00093	0.00065	0.0128	0.00266	0.0014	0.00462
Cobalt (dis)													0.00048
Cobalt Total							0.0006			0.00245	0.00068	0.00035	0.00107
Copper (dis)	0.002	0.0015	0.0017	0.00268	0.0019	0.00094	0.00076	0.00046	0.0007	0.00273	0.002	0.001	0.00408
Copper Total	0.00335	0.0042	0.00208	0.0069	0.0035	0.0015	0.00395	0.00094	0.0009	0.0154	0.00511	0.00273	0.00889
Lead (dis)	0.00025	0.00028	0.00026	0.00026	0.0002					0.00035	0.00026		
Lead Total	0.00348	0.00325	0.00283	0.0096	0.00233	0.00089	0.00606	0.00038		0.0279	0.00303	0.00123	0.00192
Molybdenum (dis)	0.0013			0.00093						0.00082			0.002
Molybdenum Total	0.0014			0.001					0.00066	0.00095			0.0023
Nickel (dis)	0.0011	0.00094	0.0014	0.0014	0.00098	0.0011	0.0012	0.00084	0.0011	0.001	0.00087	0.00088	0.00279
Nickel Total	0.00235	0.00274	0.00247	0.00502	0.00217	0.00186	0.00348	0.0011	0.0013	0.0107	0.00284	0.00203	0.00561
Vanadium (dis)	0.0009	0.0015	0.0011	0.0011	0.0014	0.0011	0.0014	0.00183	0.0014	0.00164	0.00158	0.0014	0.00568
Vanadium Total	0.00278	0.0048	0.00271	0.00587	0.00386	0.00213	0.00415	0.00252	0.00174	0.0131	0.00448	0.00249	0.016
Zinc (dis)	0.00413	0.00539	0.002	0.00638	0.00714	0.0014	0.00275	0.0013	0.00082	0.0046	0.00883	0.00286	0.00451
Zinc Total	0.0178	0.0193	0.0103	0.0502	0.0242	0.00743	0.0227	0.00339	0.0019	0.0901	0.0289	0.0119	0.0143
Hardness Calc	57.7	53.7	80.3	72.1	50.8	77.8	108	62.7	84.5	71.2	46.3	75.9	65.3

**APPENDIX D:
DETAILED AQUIRE RESULTS FOR
STUDIES SELECTED TO DEVELOP
EFFECTS THRESHOLDS**

Table D-1. AQUIRE studies used to develop effects thresholds

Analyte	Scientific Name	Common Name	Test Duration	Duration Units	Exposure Type	Endpoint	Effect	Conc	Units	Screening Threshold ¹	Author	Year	Title	Ref Source	Chem Method	Chem Comment	Organism Comment	Eff & Endpnt Comment	Exp Design Comment	Control Type	Doc Code	CAS #
2,4-D	<i>Myriophyllum spicatum</i>	Eurasian watermilfoil	11	WK	F	LOEC	GRO	30	µg/L	30	Westerdahl, H.E., and J.F. Hall	1983	Threshold 2,4-D Concentrations for Control of Eurasian Watermilfoil and Sago Pondweed	J.Aquat.Plant Manage. 21:22-25	M	NR	15 CM, MERISTEMATIC CUTTINGS		HYDROSOIL, SAND SUBSTRATE//	S	M	94757
2,6-Dichlorobenzamide	<i>Oncorhynchus mykiss</i>	Rainbow trout,donaldson trout	60	D	R	MATC	GRO	13416	µg/L	13416	Van Leeuwen, C.J., and H. Maas	1985	The Aquatic Toxicity of 2,6-Dichlorobenzamide (BAM), a Degradation Product of the Herbicide Dichlobenil	Environ.Pollut.Ser.A Ecol.Biol. 37(2):105-115	U	0.97	EMBRYO TO LARVAL		CHEM COMPOSITION RPTD//	I	M	2008584
4,4'-DDT	<i>Hyalella azteca</i>	Scud	10	D	F	LC50	MOR	0.07	µg/L	0.035	Hoke, R.A., G.T. Ankley, A.M. Cotter, T. Goldenstein, P.A. Kosian, G.L. Phipps, and F.M. Vandermeiden	1994	Evaluation of Equilibrium Partitioning Theory for Predicting Acute Toxicity of Field-Collected Sediments Contaminated with DDT, DDE and DDD to the	Environ.Toxicol.Chem. 13:157-166	M	NR	7-14 D			C	M	50293
4,4'-DDE	<i>Hyalella azteca</i>	Scud	10	D	F	LC50	MOR	1.66	µg/L	0.83	Hoke, R.A., G.T. Ankley, A.M. Cotter, T. Goldenstein, P.A. Kosian, G.L. Phipps, and F.M. Vandermeiden	1994	Evaluation of Equilibrium Partitioning Theory for Predicting Acute Toxicity of Field-Collected Sediments Contaminated with DDT, DDE and DDD to the	Environ.Toxicol.Chem. 13:157-166	M	NR	7-14 D			C	M	72559
4,4'-DDD	<i>Chironomus tentans</i>	Midge	10	D	F	LC50	MOR	0.18	µg/L	0.09	Phipps, G.L., V.R. Mattson, and G.T. Ankley	1995	Relative Sensitivity of Three Freshwater Benthic Macroinvertebrates to Ten Contaminants	Arch.Environ.Contam.Toxicol. 28(3):281-286	M	P,P'-DDD	NR			C	M	72548
4-Nitrophenol	<i>Oncorhynchus mykiss</i>	Rainbow trout,donaldson trout	85	D	F	MATC	GRO	989	µg/L	989	Hodson, P.V., R. Parisella, B. Blunt, B. Gray, and K.L.E. Kaiser	1991	Quantitative Structure-Activity Relationships for Chronic Toxicity of Phenol, p-Chlorophenol, 2,4-Dichlorophenol, Pentachlorophenol, p-Nitrophenol,	Can.Tech.Rep.Fish.Aquat.Sci. 1784:55	M	AQ	FRY		CONDUCTIVITY 244-245 UMHOS/CM//	S	C	100027
Atrazine	<i>Chlamydomonas reinhardtii</i>	Green algae	4	D	F	NOEC	POP	3.4	µg/L	3.4	Schafer, H., H. Hettler, U. Fritsche, G. Pitzen, G. Roderer, and A. Wenzel	1994	Biotefts Using Unicellular Algae and Ciliates for Predicting Long-Term Effects of Toxicants	Ecotoxicol.Environ.Saf. 27(1):64-81	M	ATRAZINE	1000 CELLS/ML, STRAIN 11-3 QA	EC10//		K	C	1912249
Barium	<i>Daphnia magna</i>	Water flea	21	D	R	EC50*	REP	8900	µg/L	4450	Biesinger, K.E., and G.M. Christensen	1972	Effects of Various Metals on Survival, Growth, Reproduction and Metabolism of Daphnia magna	J.Fish.Res.Board.Can.29:1691-1700	U	R	12 H		SEE PAPER//	I	C	10361372
Benzoic Acid	<i>Gambusia affinis</i>	Western mosquitofish	48	H	S	LC50*	MOR	225000	µg/L	112500	Wallen, I.E., W.C. Greer, and R. Lasater	1957	Toxicity to Gambusia affinis of Certain Pure Chemicals in Turbid Waters	Sewage Ind.Wastes 29(6):695-711	U	CP	ADULT, FEMALE		TURBIDITY < 25 TO 220 MG/L//	I	C	65850
Bromacil	<i>Selenastrum capricornutum</i>	Green algae	96	H	S	NOEC	POP	10	µg/L	10	Garten, C.T.J.	1990	Multispecies Methods of testing for Toxicity: Use of the Rhizobium-Legume Symbiosis in Nitrogen Fixation and Correlations Between Responses by Algae and Terrestrial Plants	In: W.Wang, J.W.Gorsuch, and W.R.Lower (Eds.), Plants for Toxicity Assessment, ASTM STP 1091, Philadelphia, PA :69-84	U	BROMACIL	3-4 D, LOG GRO PHASE/		C	C	314409	
Caffeine	<i>Pimephales promelas</i>	Fathead minnow	120	H	S	LOEC	GRO	20000	µg/L	20000	DeYoung, D.J., J.A. Bantle, M.A. Hull, and S.L. Burks	1996	Differences in Sensitivity to Developmental Toxicants as seen in Xenopus and Pimephales Embryos	Bull.Environ.Contam.Toxicol. 56(1):143-150	U	99 % PU, CAFFEINE	EMBRYO		LENGTH//	C	C	58082
Carbaryl	<i>Daphnia magna</i>	Water flea	48	H	F	EC50	ITX	6.66	ppb	3.33	Office of Pesticide Programs	1995	Environmental Effects Database (EEDB)	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	NR	NR	<24 h			K	M	63252
Cobalt	<i>Daphnia magna</i>	Water flea	28	D	R	MATC	REP	5.1	µg/L	5.1	Kimball, G.	1978	The Effects of Lesser Known Metals and One Organic to Fathead Minnows (Pimephales promelas) and Daphnia magna	Manuscript, Dep.of Entomology, Fisheries and Wildlife, University of Minnesota, Minneapolis, M N:88	U	NR	NEONATE-ADULT	MEAN YOUNG/FEMALE//		I	C	10124433
Desethylatrazine	No acceptable data found																					6190-65-4
Dicamba	<i>Anabaena flosaquae</i>	Blue-green algae	5	D	S	EC50	ITX	61	µg/L	30.5	Office of Pesticide Programs	1995	Environmental Effects Database (EEDB)	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	NR	NR	NR			K	M	1918009
Dichlobenil	<i>Daphnia magna</i>	Water flea	48	H	S	EC50	ITX	6200	µg/L	3100	Office of Pesticide Programs	1995	Environmental Effects Database (EEDB)	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	NR	NR	1st instar			K	M	1194656
Dichlorprop	<i>Oncorhynchus mykiss</i>	Rainbow trout,donaldson trout	96	H	S	LC50	MOR	2700	µg/L	1350	Office of Pesticide Programs	1995	Environmental Effects Database (EEDB)	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	NR	NR	0.35 g			K	M	120365
EPTC	<i>Misgurnus fossilis</i>	Loach	45	D	R	LOEC	MOR	1400	µg/L	1400	Perevozchenko, I.I.	1975	Effect of Carbamic and Thiocarbamic Acid Derivatives on Fishes and Amphibians	Hydrobiol.J.11(1):74-76; Gidrobiol.Zh.11(1):95-98 (RUS)	U	EMULSION 75%	NR			I	M	759944
gamma-HCH	<i>Limnephilus lunatus</i>	Caddisfly	240	H	R	LC50	MOR	0.8	µg/L	0.4	Schulz, R., and M. Liess	1995	Chronic Effects of Low Insecticide Concentrations on Freshwater Caddisfly Larvae	Hydrobiologia 299(2):103-113	U	LINDANE, EC, 80 % AI	5TH INSTAR LARVAE			NR	M	58899
MCPA	<i>Lemna minor</i>	Duckweed	24	H	S	LOEC	POP	1400	µg/L	1400	Peterson, H.G., C. Boutin, P.A. Martin, K.E. Freemark, N.J. Ruecker, and M.J. Moody	1994	Aquatic Phyto-Toxicity of 23 Pesticides Applied at Expected Environmental Concentrations	Aquat.Toxicol. 28(3/4):275-292	U	MCPA	NR		NUMBER OF LEAVES//	C	M	94746
MCPP	<i>Lemna minor</i>	Duckweed	10	D	R	EC50	POP	5147	µg/L	2573.5	Kirby, M.F., and D.A. Sheahan	1994	Effects of Atrazine, Isoproturon, and Mecoprop on the Macrophyte Lemna minor and the Alga Scenedesmus subspicatus	Bull.Environ.Contam.Toxicol. 53(1):120-126	U	98 % PU, MECOPROP	NR		FROND NUMBER//	S	M	93652
Metolachlor	<i>Selenastrum capricornutum</i>	Green algae	5	D	S	EC50	ITX	10	µg/L	5	Office of Pesticide Programs	1995	Environmental Effects Database (EEDB)	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	NR	NR	NR			K	M	51218452
Molybdenum	<i>Daphnia magna</i>	Water flea	28	D	R	MATC	REP	880	µg/L	880	Kimball, G.	1978	The Effects of Lesser Known Metals and One Organic to Fathead Minnows (Pimephales promelas) and Daphnia magna	Manuscript, Dep.of Entomology, Fisheries and Wildlife, University of Minnesota, Minneapolis, M N:88	U	NR	NEONATE-ADULT	MEAN YOUNG/FEMALE//		S	C	1313275
Napropamide	<i>Selenastrum capricornutum</i>	Green algae	96	H	S	EC50	ITX	3400	µg/L	1700	Office of Pesticide Programs	1995	Environmental Effects Database (EEDB)	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	NR	NR	NR			K	M	15299997
Prometon	<i>Selenastrum capricornutum</i>	Green algae	5	D	S	EC50	ITX	98	ppb	49	Office of Pesticide Programs	1995	Environmental Effects Database (EEDB)	Environmental Fate and Effects Division, U.S.EPA, Washington, D.C.	NR	NR	NR			K	M	1610180
Simazine	<i>Selenastrum capricornutum</i>	Green algae		WK	S	EC50	POP	0.614	µg/L	0.307	Turbak, S.C., S.B. Olson, and G.A. McFeters	1986	Comparison of Algal Assay Systems for Detecting Waterborne Herbicides and Metals	Water Res. 20(1):91-96	U	PRINCEP 4G, AGRICHEMICAL GRADE	LOG PHASE		ALGAL MEDIA//	S	C	122349
Trichlopyr	<i>Oncorhynchus keta</i>	Chum salmon	96	H	S	LC50	MOR	300	µg/L	150	Wan, M.T., D.J. Moul, and R.G. Watts	1987	Acute Toxicity to Juvenile Pacific Salmonids of Garlon 3A, Garlon 4,	Bull.Environ.Contam.Toxicol. 39(4):721-728	M	99.7 % PU	JUVENILE, 4.5(3.9-5.0) CM//		METAL ION CONC MEASURED//	S	C	55335063
Trifluralin	<i>Pimephales promelas</i>	Fathead minnow	427	D/	F	MATC	REP	3.154	µg/L	3.154	Macek, K.J., M.A. Lindberg, S. Sauter, K.S. Buxton, and P.A. Costa	1976	Toxicity of Four Pesticides to Water Fleas and Fathead Minnows	EPA-600/3-76-099, Environ.Res.Lab., U.S.Environ.Prot.Agency, Duluth, M N:68	M	0.97	2ND GENERATION		ACIDITY, 4.2 (2.0-7.0) AND CHEM ANALYSIS OF WATER//	U	M	1582098
Vanadium	<i>Jordanella floridae</i>	Flagfish	96	D	F	MATC	GRO	80	µg/L	80	Holdway, D.A., and J.B. Sprague	1979	Chronic Toxicity of Vanadium to Flagfish	Water Res. 13(9):905-910	M	NR	LARVAE, 1 WK-2ND GENERATION			S	M	1314621

¹ Per Stephan et al (1985), when the screening threshold was based upon an EC/LC50, the value was divided by 2.

**APPENDIX E:
COMPARISON OF PESTICIDE AND
METAL CONCENTRATIONS TO
EFFECTS THRESHOLDS**

Table E-1. Ratios of Pesticide Concentrations to Effects Thresholds (All Units µg/L).

Parameter	Effects Threshold	Lyon Creek				Little Bear Creek				Swamp Creek				Sammamish Irrigation Return
		Early May-00	Late May-00	Jun-00	Oct-00	Early May-00	Late May-00	Jun-00	Oct-00	Early May-00	Late May-00	Jun-00	Oct-00	Sep-00
2,4-D	12.5	0.0160	0.0232	--	0.0160	0.0184	0.0144	--	0.0416	0.0046	0.0044	--	0.0096	0.0224
2,6-Dichlorobenzamide	13,416	--	--	--	--	--	--	--	--	--	--	--	--	0.0000
4-Nitrophenol	150	--	--	--	0.0019	0.0000	--	--	--	--	--	0.00005	--	--
Atrazine	0.05	0.3400	0.1600	0.0800	--	0.1000	--	--	--	--	--	0.1400	--	--
Bromacil	3.4	--	0.0038	0.0147	--	--	--	--	--	--	--	--	--	--
Carbaryl	3.33	0.0622	0.0492	--	--	0.0054	--	--	--	--	--	--	--	--
Carbofuran	0.764	--	--	--	--	--	--	--	--	--	--	--	--	0.2999
Chlorpyrifos	0.03	0.1000	0.1000	--	--	--	--	--	--	--	--	--	--	0.1667
Desethylatrazine	N/A	--	--	N/A	--	--	--	N/A	--	--	--	--	--	--
Diazinon	0.09	0.6556	1.1000	0.0556	0.4889	0.0889	0.0778	0.0633	0.1089	0.2778	0.3333	0.0444	0.3222	6.5111
Dicamba	30.5	--	--	--	0.0009	--	--	--	0.0004	--	--	--	--	0.0125
Dichlobenil	3,100	0.00004	0.00003	0.00000	0.00002	0.00001	0.000004	0.00002	0.00001	0.00001	0.000004	0.00002	0.00001	0.0000
Diuron	1.2	--	--	--	--	--	--	--	--	--	--	--	--	0.0433
Ethofumesate	18709	--	--	--	--	--	--	--	--	--	--	--	--	0.0001
Malathion	0.1	--	--	--	--	--	--	--	--	0.3200	0.2100	--	--	--
MCPA	1400	0.00004	0.00003	--	--	0.00001	--	--	--	0.00002	0.00002	--	--	--
MCPP	2,573.50	0.0000	0.0001	0.0000	0.0002	0.0001	0.00002	--	0.0001	0.00003	0.00003	--	0.0001	--
Metalaxyl	5	--	--	--	--	--	--	--	--	--	--	--	--	0.0300
Metolachlor	5	--	--	--	--	--	--	--	--	--	--	--	--	0.0014
Pentachlorophenol ¹	6.25	--	--	--	--	--	0.0043	--	0.0083	0.0032	0.0022	--	0.0126	0.0046
Prometon	49	0.0007	0.0009	0.0002	0.0004	0.0001	0.0002	0.0001	0.0003	0.0004	0.0004	0.0002	0.0002	0.0001
Simazine	0.307	0.1075	0.1466	0.0261	0.3257	--	--	0.0163	--	--	--	0.0228	--	--
Tebuthiuron	153.5	--	--	0.0001	--	0.0001	0.0001	0.0001	--	--	--	--	--	0.0005
Trichlorpyr	25	0.0040	0.0024	--	0.0040	0.0072	0.0060	--	0.0296	0.0048	0.0052	--	0.0040	0.0112
Trifluralin	3.154	--	--	0.0010	--	--	--	--	--	--	--	--	--	0.0010
Max Ratio		0.6556	1.1000	0.0800	0.4889	0.1000	0.0778	0.0633	0.1089	0.3200	0.3333	0.1400	0.3222	6.5111
# of Ratios > 1.0		0	1	0	0	0	0	0	0	0	0	0	0	1

Table E-2. Early in May Storm Event: Ratios of metal concentrations to effects thresholds.

Chemical	Lyon Creek					Little Bear Creek					Swamp Creek				
	Effects Threshold (µg/L)	Conc. (µg/L)	MDL (µg/L)	Adjusted Conc. (µg/L)	HQ	Effects Threshold (µg/L)	Conc. (µg/L)	MDL (µg/L)	Adjusted Conc. (µg/L)	HQ	Effects Threshold (µg/L)	Conc. (µg/L)	MDL (µg/L)	Adjusted Conc. (µg/L)	HQ
Antimony	30	0.54	0.5	0.54	0.018	30	<MDL	0.5	0.25	0.008	30	<MDL	0.5	0.25	0.008
Arsenic	190	2.69	0.5	2.69	0.014	190	1.3	0.5	1.3	0.007	190	1.3	0.5	1.3	0.007
Barium	4450	27.6	0.2	27.6	0.006	4450	18	0.2	18	0.004	4450	15.3	0.2	15.3	0.003
Beryllium	5.3	<MDL	0.2	0.1	0.019	5.3	<MDL	0.2	0.1	0.019	5.3	<MDL	0.2	0.1	0.019
Cadmium ^a	0.810	<MDL	0.1	0.05	0.062	0.625	<MDL	0.1	0.05	0.080	0.856	<MDL	0.1	0.05	0.058
Chromium	100.9	5.39	0.4	5.39	0.053	100.9	2.22	0.4	2.22	0.022	100.9	1.4	0.4	1.4	0.014
Cobalt	5.1	<MDL	0.2	0.1	0.020	5.1	<MDL	0.2	0.1	0.020	5.1	<MDL	0.2	0.1	0.020
Copper ^a	8.583	2.68	0.4	2.68	0.312	6.363	1.9	0.4	1.9	0.299	9.160	0.94	0.4	0.94	0.103
Lead ^a	1.759	0.26	0.2	0.26	0.148	1.195	0.2	0.2	0.2	0.167	1.913	<MDL	0.2	0.1	0.052
Molybdenum	880	<MDL	0.5	0.25	0.000	880	1	0.5	1	0.001	880	<MDL	0.5	0.25	0.000
Nickel ^a	119.191	1.4	0.3	1.40	0.012	88.632	0.98	0.3	0.98	0.011	127.116	1.1	0.3	1.1	0.009
Vanadium	80	5.87	0.3	5.87	0.073	41	3.86	0.3	3.86	0.094	41	2.13	0.3	2.13	0.052
Zinc ^a	79.210	6.38	0.5	6.38	0.081	58.874	7.14	0.5	7.14	0.121	84.484	1.4	0.5	1.4	0.017
Hardness (mg/L)		72.1					50.8					77.8			
Max Ratio					0.312					0.299					0.103
# of Ratios >1					0					0					0

^aEffects threshold is hardness dependent

Table E-3. Late in May Storm Event: Ratios of metal concentrations to effects thresholds.

Chemical	Lyon Creek					Little Bear Creek					Swamp Creek				
	Effects Threshold (µg/L)	Conc. (µg/L)	MDL (µg/L)	Adjusted Conc. (µg/L)	HQ	Effects Threshold (µg/L)	Conc. (µg/L)	MDL (µg/L)	Adjusted Conc. (µg/L)	HQ	Effects Threshold (µg/L)	Conc. (µg/L)	MDL (µg/L)	Adjusted Conc. (µg/L)	HQ
Antimony	30	<MDL	0.5	0.25	0.008	30	<MDL	0.5	0.25	0.008	30	<MDL	0.5	0.25	0.008
Arsenic	190	0.68	0.5	0.68	0.004	190	1.4	0.5	1.4	0.007	190	1.2	0.5	1.2	0.006
Barium	4450	14.2	0.2	14.2	0.003	4450	20.5	0.2	20.5	0.005	4450	18.6	0.2	18.6	0.004
Beryllium	5.3	<MDL	0.2	0.1	0.019	5.3	<MDL	0.2	0.1	0.019	5.3	<MDL	0.2	0.1	0.019
Cadmium ^a	0.686	<MDL	0.1	0.05	0.073	0.651	<MDL	0.1	0.05	0.077	0.877	<MDL	0.1	0.05	0.057
Chromium	100.9	2.11	0.4	2.11	0.021	100.9	2.62	0.4	2.62	0.026	100.9	1.6	0.4	1.6	0.016
Cobalt	5.1	<MDL	0.2	0.1	0.020	5.1	<MDL	0.2	0.1	0.020	5.1	<MDL	0.2	0.1	0.020
Copper ^a	7.095	2.00	0.4	2	0.282	6.673	1.50	0.4	1.5	0.225	9.410	1.7	0.4	1.7	0.181
Lead ^a	1.376	0.25	0.2	0.25	0.182	1.271	0.28	0.2	0.28	0.220	1.980	0.26	0.2	0.26	0.131
Molybdenum	880	<MDL	0.5	0.25	0.000	880	1.4	0.5	1.4	0.002	880	<MDL	0.5	0.25	0.000
Nickel ^a	98.716	1.1	0.3	1.1	0.011	92.894	0.94	0.3	0.94	0.010	130.563	1.4	0.3	1.4	0.011
Vanadium	80	2.78	0.3	2.78	0.035	41	4.8	0.3	4.8	0.117	41	2.71	0.3	2.71	0.066
Zinc ^a	65.583	4.13	0.5	4.13	0.063	61.710	5.39	0.5	5.39	0.087	86.779	2	0.5	2	0.023
Hardness (mg/L)		57.7					53.7					80.3			
Max Ratio					0.282					0.225					0.181
# of Ratios >1					0					0					0

^aEffects threshold is hardness dependent

Table E-4. June Baseline: Ratios of metal concentrations to effects thresholds.

Chemical	Lyon Creek					Little Bear Creek					Swamp Creek				
	Effects Threshold (µg/L)	Conc. (µg/L)	MDL (µg/L)	Adjusted Conc. (µg/L)	HQ	Effects Threshold (µg/L)	Conc. (µg/L)	MDL (µg/L)	Adjusted Conc. (µg/L)	HQ	Effects Threshold (µg/L)	Conc. (µg/L)	MDL (µg/L)	Adjusted Conc. (µg/L)	HQ
Aluminum	87	--			--	87	165	4	165	1.897	87	--	4	--	--
Antimony	30	<MDL	0.5	0.25	0.008	30	<MDL	0.5	0.25	0.008	30	<MDL	0.5	0.25	0.008
Arsenic	190	1.5	0.5	1.5	0.008	190	1.8	0.5	1.8	0.009	190	1.6	0.5	1.6	0.008
Barium	4450	21	0.2	21	0.005	4450	12	0.2	12	0.003	4450	12	0.2	12	0.003
Beryllium	5.3	<MDL	0.2	0.1	0.019	5.3	<MDL	0.2	0.1	0.019	5.3	<MDL	0.2	0.1	0.019
Cadmium ^a	1.091	<MDL	0.1	0.05	0.046	0.730	<MDL	0.1	0.05	0.068	0.910	<MDL	0.1	0.05	0.055
Chromium	100.9	3.16	0.4	3.16	0.031	100.9	0.93	0.4	0.93	0.009	100.9	0.65	0.4	0.65	0.006
Copper ^a	12.122	0.76	0.4	0.76	0.063	7.617	0.46	0.4	0.46	0.060	9.829	0.7	0.4	0.7	0.071
Lead ^a	2.736	<MDL	0.2	0.1	0.037	1.509	<MDL	0.2	0.1	0.066	2.094	<MDL	0.2	0.1	0.048
Molybdenum	880	<MDL	0.5	0.25	0.000	880	<MDL	0.5	0.25	0.000	880	<MDL	0.5	0.25	0.000
Nickel ^a	167.767	1.2	0.3	1.2	0.007	105.906	0.84	0.3	0.84	0.008	136.318	1.1	0.3	1.1	0.008
Zinc ^a	111.550	2.75	0.5	2.75	0.025	70.368	1.30	0.5	1.3	0.018	90.610	0.82	0.5	0.82	0.009
Hardness (mg/L)		108					62.7					84.5			
Max Ratio					0.063					1.897					0.071
# of Ratios >1					0					1					0

^aEffects threshold is hardness dependent
Boxed cells represent ratios >1

Table E-5. October Storm: Ratios of metal concentrations to effects thresholds.

Chemical	Lyon Creek					Little Bear Creek					Swamp Creek				
	Effects Threshold (µg/L)	Conc. (µg/L)	MDL (µg/L)	Adjusted Conc. (µg/L)	HQ	Effects Threshold (µg/L)	Conc. (µg/L)	MDL (µg/L)	Adjusted Conc. (µg/L)	HQ	Effects Threshold (µg/L)	Conc. (µg/L)	MDL (µg/L)	Adjusted Conc. (µg/L)	HQ
Antimony	30	0.76	0.5	0.76	0.025	30	0.81	0.5	0.81	0.027	30	<MDL	0.5	0.25	0.008
Arsenic	190	1.4	0.5	1.4	0.007	190	1.3	0.5	1.3	0.007	190	1.6	0.5	1.6	0.008
Barium	4450	57.2	0.2	57.2	0.013	4450	19.3	0.2	19.3	0.004	4450	15.4	0.2	15.4	0.003
Beryllium	5.3	<MDL	0.2	0.1	0.019	5.3	<MDL	0.2	0.1	0.019	5.3	<MDL	0.2	0.1	0.019
Cadmium ^a	0.802	<MDL	0.1	0.05	0.062	0.583	<MDL	0.1	0.05	0.086	0.841	<MDL	0.1	0.05	0.059
Chromium	100.9	12.8	0.4	12.8	0.127	100.9	2.66	0.4	2.66	0.026	100.9	1.4	0.4	1.4	0.014
Cobalt	5.1	<MDL	0.2	0.1	0.020	5.1	<MDL	0.2	0.1	0.020	5.1	<MDL	0.2	0.1	0.020
Copper ^a	8.491	2.73	0.4	2.73	0.322	5.879	2.00	0.4	2	0.340	8.968	1	0.4	1	0.112
Lead ^a	1.735	0.35	0.2	0.35	0.202	1.078	0.26	0.2	0.26	0.241	1.862	<MDL	0.2	0.1	0.054
Molybdenum	880	0.66	0.5	0.66	0.001	880	0.95	0.5	0.95	0.001	880	<MDL	0.5	0.25	0.000
Nickel ^a	117.931	1	0.3	1	0.008	81.943	0.87	0.3	0.87	0.011	124.485	0.88	0.3	0.88	0.007
Vanadium	80	13.1	0.3	13.1	0.164	41	4.48	0.3	4.48	0.109	41	2.49	0.3	2.49	0.061
Zinc ^a	78.371	4.60	0.5	4.6	0.059	54.425	8.83	0.5	8.83	0.162	82.733	2.86	0.5	2.86	0.035
Hardness (mg/L)		71.2					46.3					75.9			
Max Ratio					0.32					0.340					0.112
# of Ratios >1					0					0					0

^aEffects threshold is hardness dependent

Table E-6. Ratios of metal concentrations in the Sammamish River Irrigation Return to effects thresholds.

Chemical	Sammamish River Irrigation Return				
	Effects Threshold (µg/L)	Conc. (µg/L)	MDL (µg/L)	Adjusted Conc. (µg/L)	HQ
Aluminum	87	3320	200	3320	38.16
Antimony	30	<MDL	0.5	0.25	0.008
Arsenic	190	1.7	0.5	1.7	0.009
Barium	4450	42.5	0.2	42.5	0.010
Beryllium	5.3	<MDL	0.2	0.1	0.019
Cadmium ^a	0.752	<MDL	0.1	0.05	0.066
Chromium	100.9	4.62	0.4	4.62	0.046
Cobalt	5.1	0.48	0.2	0.48	0.094
Copper ^{a,b}	7.886	4.08	0.4	4.08	0.517
Lead ^{a,b}	1.578	<MDL	0.2	0.1	0.063
Molybdenum	880	2.3	0.5	2.3	0.003
Nickel ^a	109.609	2.79	0.3	2.79	0.025
Vanadium	80	16	0.3	16	0.200
Zinc ^{a,b}	72.832	4.51	0.5	4.51	0.062
Hardness (mg/L)		65.3			
Max Ratio					38.16
# of Ratios >1					1

APPENDIX F:
DETAILED TOXICITY TEST RESULTS
FOR 2000 SMALL STREAMS STUDY

SPRING 2000 TEST RESULTS

Storm event samples were collected from Lyon, Little Bear, and Swamp Creeks on May 3, 2000. The King County Environmental Laboratory (KCEL) received the samples on May 3, 2000, and *Selenastrum capricornutum* and *Lemna minor* chronic toxicity tests were initiated within 36 hours of their collection. The *Ceriodaphnia dubia* bioassay was initiated within 60 hours of collection.

Unfiltered Spring 2000 Results

Table F-1. Unfiltered Stream Water Collected During Spring 2000 Storm Event

Sample Site	Collection time	<i>C. dubia</i> Mean 7-Day Reproduction	<i>S. capricornutum</i> 96-Hour Mean Cell Counts (cells/mL x 10 ⁴)	<i>L. minor</i> 7-Day Chronic Toxicity (Dry Weight, mg)
In-House Control ¹	N/A	25.8	310.3	10.43
Rock Creek (Reference)	N/A	22.5	14.0	13.42
Lyon Creek	Early	23.9	231.4	10.44*
Swamp Creek	Early	19.2	47.6	9.07*
Little Bear Creek	Early	26.6	7.3*	15.15
Lyon Creek	Late	27.3	215	11.96
Swamp Creek	Late	29.1	41.7	7.16*
Little Bear Creek	Late	24.9	8.5*	16.22

¹In-house control is Lake Washington water (LWW) for *C. dubia*, algal assay medium (AAM) for *S. capricornutum*, and Hoagland's medium for *L. minor*.

*Significantly less compared to unfiltered Rock Creek sample ($p < 0.05$; 1-tailed t-Test).

N/A = Not applicable

Reproduction by *C. dubia* was not significantly reduced ($p > 0.05$; 1-tailed homoscedastic t-Test) in any sample (regardless of collection during the early or late part of the storm event) when compared to the unfiltered Rock Creek reference sample (Table F-1). This indicates that chronic toxicity to *C. dubia* was not associated with the Lyon, Swamp, or Little Bear Creek samples. Reproduction in the Rock Creek reference was similar ($p > 0.05$, t-Test) to that in the LWW (Lake Washington water) in-house control, indicating that Rock Creek provided a suitable reference.

Growth of *S. capricornutum* in unfiltered samples was not significantly ($p > 0.05$; 1-tailed heteroscedastic t-Test) reduced in Lyon and Swamp Creeks (regardless of collection during the early or late part of the storm event) when compared to the unfiltered Rock Creek reference sample (Table F-1). Growth of *S. capricornutum* was significantly reduced in samples from Little Bear Creek collected early and late in the storm event when (Table F-1). It should be noted that the *S. capricornutum* tests conducted in Rock Creek water did not meet the criteria for control acceptability. The density of *S. capricornutum* in the test control should have averaged at least 100×10^4 cells/mL. The average density of *S. capricornutum* in the unfiltered Rock Creek water was only 14.0×10^4 cells/mL.

The mean 7-day dry weight of *L. minor* was significantly reduced ($p < 0.05$; 1-tailed homoscedastic t-Test) in Lyon (early in storm) and Swamp Creek (early and late in storm)

samples, when compared to results in Rock Creek water (Table F-1). The mean 7-day dry weight of *L. minor* in Little Bear Creek samples was not reduced relative to the Rock Creek reference. In addition, plants grown in the Swamp Creek samples were noticeably chlorotic and generally less healthy appearing than those in the other samples or in the reference. The mean dry weight of *L. minor* in water from Rock Creek was not significantly different than the mean weight of *L. minor* grown in Hoagland's medium, indicating it is an acceptable control.

Filtered Spring 2000 Results

A portion of the stream water sampled was passed through a 0.45 µm capsule filter and used in *C. dubia* and *S. capricornutum* bioassays. Filtration was performed to determine if the observed reduction in reproduction of growth in stream samples is due to constituents dissolved in the stream water or associated with particulates.

Table F-2. Filtered Stream Water Collected During Spring 2000 Storm Event

Sample Site	Collection time	<i>C. dubia</i> Mean 7-Day Reproduction	<i>S. capricornutum</i> 96-Hour Mean Cell Counts (cells/mL x 10 ⁴)
In-House Control ¹	N/A	25.8	273.9
Rock Creek (Reference)	N/A	20.3	310.5
Lyon Creek	Early	NT	215.1*
Swamp Creek	Early	NT	301.3
Little Bear Creek	Early	NT	318.8
Lyon Creek	Late	23.1	323.6
Swamp Creek	Late	21.0	303.2
Little Bear Creek	Late	22.9	344

¹In-house control is Lake Washington water (LWW) for *C. dubia* and algal assay medium (AAM) for *S. capricornutum*.

*Significantly less compared to filtered Rock Creek sample ($p < 0.05$; 1-tailed t-Test).

NT = Not tested

N/A = Not applicable

As shown in the Table F-2, the reproductive response of *C. dubia* was not significantly reduced ($p > 0.05$; 1-tailed homoscedastic t-Test) in any sample collected during the late part of the storm when compared to the filtered Rock Creek reference sample. Therefore, chronic toxicity to *C. dubia* was not associated with the Lyon, Swamp or Little Bear Creek samples.

Growth of *S. capricornutum* was significantly reduced in Lyon Creek Early filtered ($p < 0.05$; 1-tailed heteroscedastic t-Test) compared to the filtered Rock Creek reference. The vast difference between the growth of *S. capricornutum* in unfiltered and filtered Rock Creek (reference) samples suggests that particulates in the water may inhibit growth of the algae. This also likely explains the same patterns observed in the test creeks. It is unlikely that particulate-associated chemicals are contributing to growth reduction in the algae because these would have limited bioavailability to *S. capricornutum*.

SUMMER BASELINE 2000 RESULTS

Samples were collected at Rock Creek, Lyon Creek, Little Bear Creek, and Swamp Creek sites during a non-storm event on June 27, 2000. The KCEL received the three samples at 4:28 PM on June 27, 2000, with approximately 8 L of each sample in four 1/2-gallon glass jars/sample. The *C. dubia*, *S. capricornutum*, and *L. minor* chronic toxicity tests were initiated within 20 hours of the collection on June 28, 2000. Results of these tests are provided in Tables F-3 and F-4.

Unfiltered Summer 2000 Results

Table F-3. Unfiltered Water Collected for Summer Baseline Testing 2000

Sample Site	<i>C. dubia</i> Mean 7-Day Reproduction	<i>S. capricornutum</i> Mean 96-Hour Cell Counts (Cells/mL x 10 ⁴)	<i>L. minor</i> Mean 7-Day Dry Weight (mg)
In-House Control ¹	23.4	296.3	16.6
Rock Creek (Reference)	25.6	314.4	16.8
Lyon Creek	27.5	255.8*	7.7*
Swamp Creek	23.0	247.8*	7.6*
Little Bear Creek	23.5	203.2*	12.5*

¹In-house control is Lake Washington water (LWW) for *C. dubia*, algal assay medium (AAM) for *S. capricornutum*, and Hoagland's medium for *L. minor*.

*Significantly less compared to unfiltered Rock Creek sample ($p < 0.05$, 1-tailed t-Test).

Reproduction in *C. dubia* was not significantly reduced ($p > 0.05$; 1-tailed homoscedastic t-Test) in any unfiltered sample when compared to the unfiltered Rock Creek reference sample (Table F-3). Reproduction in the unfiltered Rock Creek reference was similar ($p > 0.05$, t-Test) to that in the unfiltered LWW in-house control, indicating that Rock Creek provided a suitable reference.

Growth of *S. capricornutum* was significantly ($p < 0.05$; 1-tailed heteroscedastic t-Test) reduced in unfiltered Lyon Creek, Little Bear Creek, and Swamp Creek samples compared to the unfiltered Rock Creek reference (Table F-3). The growth differences between Rock Creek and the test creeks could be due to one or more of a variety factors, including particulate concentration, nutrient availability, and elevated chemical levels. Growth of *S. capricornutum* in the unfiltered Rock Creek reference sample was not significantly different than growth in the unfiltered in-house control, algal assay medium (AAM), indicating Rock Creek was an appropriate control under baseline conditions.

The mean 7-day dry weight of *L. minor* was significantly reduced ($p < 0.05$; 1-tailed homoscedastic t-Test) in Lyon, Little Bear, and Swamp Creek samples, when compared to the Rock Creek reference (Table F-3). Like *S. capricornutum*, there are a number of variables that could influence growth of algae. The mean dry weight of *L. minor* in water from Rock Creek was not significantly different than *L. minor* grown in 10% Hoagland's medium, indicating Rock Creek was an appropriate control for baseline conditions.

Filtered Summer 2000 Results

C. dubia and *S. capricornutum* were the only bioassays conducted using filtered stream water.

Table F-4. Filtered Water Collected for Summer Baseline Testing 2000

Sample Site	<i>C. dubia</i> Mean 7-Day Reproduction	<i>S. capricornutum</i> Mean 96-Hour Cell Counts (Cells/mL x 10 ⁴)
In-House Control ¹	23.4	323.4
Rock Creek (Reference)	23.1	291.8
Lyon Creek	24.9	338.8
Swamp Creek	20.6*	347.4
Little Bear Creek	24.6	313.3

¹In-house control is Lake Washington water (LWW) for *C. dubia* and algal assay medium (AAM) for *S. capricornutum*.

*Significantly less compared to filtered Rock Creek sample ($p < 0.05$, 1-tailed t-Test).

Reproduction in *C. dubia* was not significantly reduced ($p > 0.05$; 1-tailed homoscedastic t-Test) in the filtered Lyon Creek and Little Bear Creek samples when compared to the filtered Rock Creek reference sample (Table F-4). However, reproduction was significantly ($p < 0.05$; 1-tailed homoscedastic t-Test) reduced in *C. dubia* tested in the filtered Swamp Creek sample (Table F-4).

Growth of *S. capricornutum* was not significantly reduced ($p > 0.05$; 1-tailed heteroscedastic t-Test), in the filtered Lyon, Little Bear, and Swamp Creek samples compared to the filtered Rock Creek reference (Table F-4). This indicates that the factors responsible for the observed growth reduction in unfiltered samples collected in June 2000 were removed or sufficiently reduced through filtration of the samples.

SAMMAMISH IRRIGATION RETURN RESULTS

A grab sample was collected from the 145th Street Irrigation Return to the Sammamish River on September 11, 2000. The KCEL received the samples at 2:15 PM on September 11, 2000, with approximately 6 L of sample in four 1/2-gallon glass jars. The Rock Creek Reference was collected as a grab sample on September 11, 2000 in a 5-gallon glass carboy. The *C. dubia*, *S. capricornutum*, and *L. minor* chronic toxicity tests were initiated within 20 hours of collection on September 12, 2000.

Unfiltered Sammamish Irrigation Return Results

Table F-5. Unfiltered Stream Samples Collected from a Sammamish Irrigation Return

Sample Site	<i>C. dubia</i> Mean 7-Day Reproduction	<i>S. capricornutum</i> Mean 96-Hour Cell Counts (Cells/mL x 10 ⁴)	<i>L. minor</i> Mean 7-Day Dry Weight (mg)
In-House Control ¹	21.9	350.3	12.3
Rock Creek (Reference)	21.1	323.9	12.2
Samm. Irrigation Return	0.2*	90.2*	14.4

¹In-house control is Lake Washington water (LWW) for *C. dubia*, algal assay medium (AAM) for *S. capricornutum*, and Hoagland's medium for *L. minor*.

*Significantly ($p < 0.05$) less compared to unfiltered Rock Creek sample.

Reproduction of *C. dubia* was significantly reduced ($p < 0.05$; 1-tailed homoscedastic t-Test) in the unfiltered Sammamish Irrigation Return sample when compared to the unfiltered Rock Creek reference sample (Table F-5). Not shown in Table F-5 is survival of *C. dubia* in the unfiltered Sammamish Irrigation Return sample, which was 0% at the end of the test, compared to 100% survival in the unfiltered Rock Creek reference (some reproduction occurred in the Sammamish Irrigation Return sample before all organisms died).

Growth of *S. capricornutum* was significantly ($p < 0.05$; 1-tailed heteroscedastic t-Test) reduced in the unfiltered Sammamish Irrigation Return sample as compared to the unfiltered Rock Creek reference (Table F-5).

Growth of *L. minor* was not inhibited by exposure to Sammamish Irrigation Return water when compared to growth in Rock Creek water (Table F-5). *L. minor* grown in the Sammamish Irrigation Return water did show some unnatural root loss, but this did not affect the growth measurements. Growth in the Rock Creek reference sample was similar to growth in the in-house control, 10% Hoagland's medium, indicating that Rock Creek is a suitable reference.

Filtered Sammamish Irrigation Return Results

Table F-6. Filtered Stream Samples Collected From a Sammamish Irrigation Return

Sample Site	<i>C. dubia</i> Mean 7-Day Reproduction	<i>S. capricornutum</i> Mean 96-Hour Cell Counts (Cells/mL x 10 ⁴)
In-House Control ¹	21.9	326.1
Rock Creek	17.9	363.6
Samm. Irrigation Return	5*	371.1

¹In-house control is Lake Washington water (LWW) for *C. dubia* and algal assay medium (AAM) for *S. capricornutum*.

*Significantly ($p < 0.05$) less compared to filtered Rock Creek sample.

NT = Not tested

Reproduction in *C. dubia* was significantly reduced ($p < 0.05$; 1-tailed homoscedastic t-Test) in the filtered Sammamish Irrigation Return sample when compared to the unfiltered Rock Creek reference sample (Table F-6). Again there was 0% survival of *C. dubia* in the filtered Sammamish Irrigation Return sample, and 100% survival of *C. dubia* in the filtered Rock Creek reference sample (some reproduction occurred in the Sammamish Irrigation Return sample before all organisms died).

Growth of *S. capricornutum* was not significantly ($p < 0.05$; 1-tailed heteroscedastic t-Test) reduced in the filtered Sammamish Irrigation Return sample compared to the filtered Rock Creek reference (Table F-6). This indicates filtration removed the cause of the observed growth reduction in *S. capricornutum* in the unfiltered sample from the irrigation return stream.

FALL 2000 RESULTS

Three 24-hour composite stormwater samples were collected at the Lyon Creek, Swamp Creek and Little Bear Creek sites on October 9-10, 2000. The KCEL received the samples at 1145h on October 10, 2000, with approximately 8 L of each sample in four-quart glass jars/sample. Approximately 30 L total of the Rock Creek Reference was collected as a grab sample at 1010h on October 10, 2000 in two 5-gallon glass carboys. The *C. dubia*, *S. capricornutum*, and *L. minor* chronic toxicity tests were initiated within 27 hours of collection on October 11, 2000.

Unfiltered Fall 2000 Results

Table F-7. Unfiltered Stream Samples Collected for Fall 2000 Testing

Sample Site	<i>C. dubia</i> Mean 7-Day Reproduction	<i>S. capricornutum</i> Mean 96-Hour Cell Counts (Cells/mL x 10 ⁴)	<i>L. minor</i> Mean 7-Day Dry Weight (mg)
In-House Control ¹	17.6	295.4	13.7
Rock Creek (Reference)	19.2	304.0	13.1
Lyon Creek	22.2	147.3*	17.0
Swamp Creek	22.8	85.7*	13.6
Little Bear Creek	22.4	228.1*	17.4

¹In-house control is Lake Washington water (LWW) for *C. dubia*, algal assay medium (AAM) for *S. capricornutum*, and Hoagland's medium for *L. minor*.

*Significantly ($p < 0.05$) less compared to unfiltered Rock Creek sample.

NA = Not available.

Reproduction in *C. dubia* was not significantly reduced ($p > 0.05$; 1-tailed homoscedastic t-Test) in any unfiltered sample when compared to the unfiltered Rock Creek reference sample (Table F-7). Reproduction in the unfiltered Rock Creek reference was similar ($p > 0.05$, t-Test) to that in the unfiltered LWW in-house control, indicating that Rock Creek provided a suitable reference.

S. capricornutum growth was significantly reduced ($p > 0.05$; 1-tailed heteroscedastic t-Test) in unfiltered Lyon Creek, Little Bear Creek, and Swamp Creek samples compared to the unfiltered Rock Creek reference (Table F-7). Growth of *S. capricornutum* in the unfiltered Rock Creek water was not significantly ($p > 0.05$; 1-tailed heteroscedastic t-Test) reduced compared to unfiltered AAM, indicating Rock Creek was an appropriate control site.

Growth of *L. minor* was not affected by exposure to unfiltered Lyon Creek, Little Bear Creek, and Swamp Creek water when compared to Rock Creek (Table F-7). Growth in the Rock Creek reference sample was similar to growth in the control, 10% Hoagland's medium, indicating that Rock Creek is a suitable reference site.

Filtered Fall 2000 Results

Table F-8. Filtered stream water collected for fall 2000 testing.

Sample Site	<i>C. dubia</i> Mean 7-Day Reproduction	<i>S. capricornutum</i> Mean 96-Hour Cell Counts (Cells/mL x 10 ⁴)
In-House Control ¹	17.6	340.5
Rock Creek (Reference)	14.8	312.3
Lyon Creek	16.1	331.5
Swamp Creek	16.9	389.9
Little Bear Creek	17.0	283.6

¹In-house control is Lake Washington water (LWW) for *C. dubia* and algal assay medium (AAM) for *S. capricornutum*.

*Significantly ($p < 0.05$) less compared to filtered Rock Creek sample.

NT = Not tested

Reproduction of *C. dubia* was not significantly reduced ($p > 0.05$; 1-tailed homoscedastic t-Test) in filtered Lyon, Swamp or Little Bear Creek samples when compared to the filtered Rock Creek reference sample (Table F-8), indicating chronic toxicity to *C. dubia* is not associated with these creeks. Reproduction in the filtered Rock Creek reference was significantly reduced compared to the LWW in-house control, and did not meet control acceptability standards outlined in Table 4-1. However, when compared to LWW in-house controls, reproduction in *C. dubia* was not significantly reduced in the filtered Lyon, Swamp or Little Bear Creek samples.

There was no significant difference ($p > 0.05$; 1-tailed heterostatic t-Test) in the growth of *S. capricornutum* in Lyon, Little Bear, and Swamp Creek samples compared to the Rock Creek sample (Table F-8). Filtration of the stream samples removed the source of the growth reduction observed in unfiltered samples from the three urban streams.